Demonstration of the radar data assimilation on the QPF of the severe frontal rainfall event

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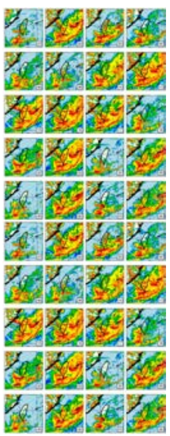
Central Weather Bureau

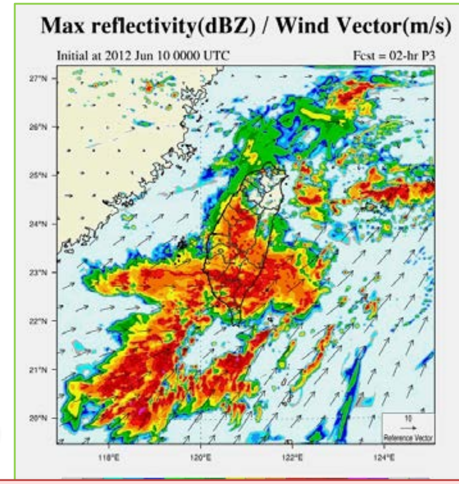
Radar DA in CWB



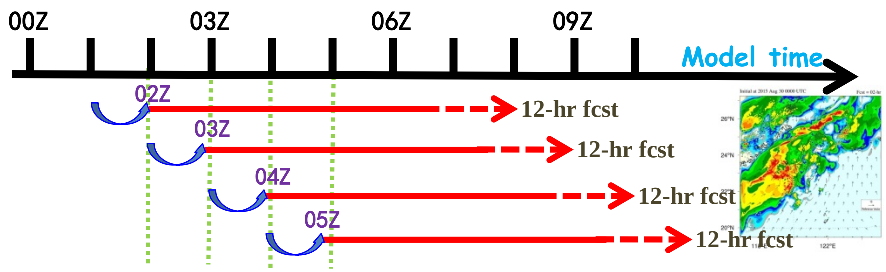
LETKF

Hybrid 3DEnVAR

Ensemble mean

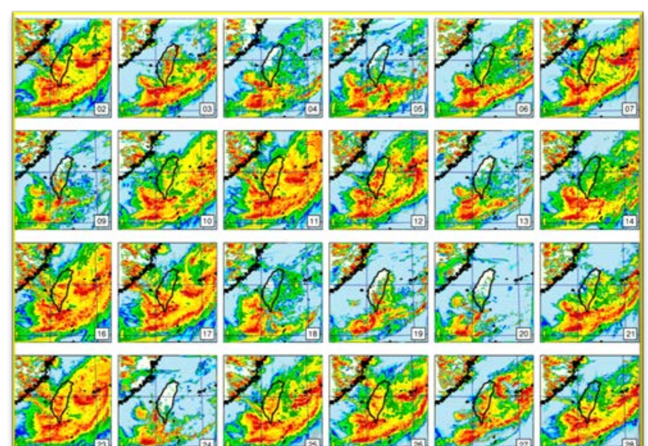


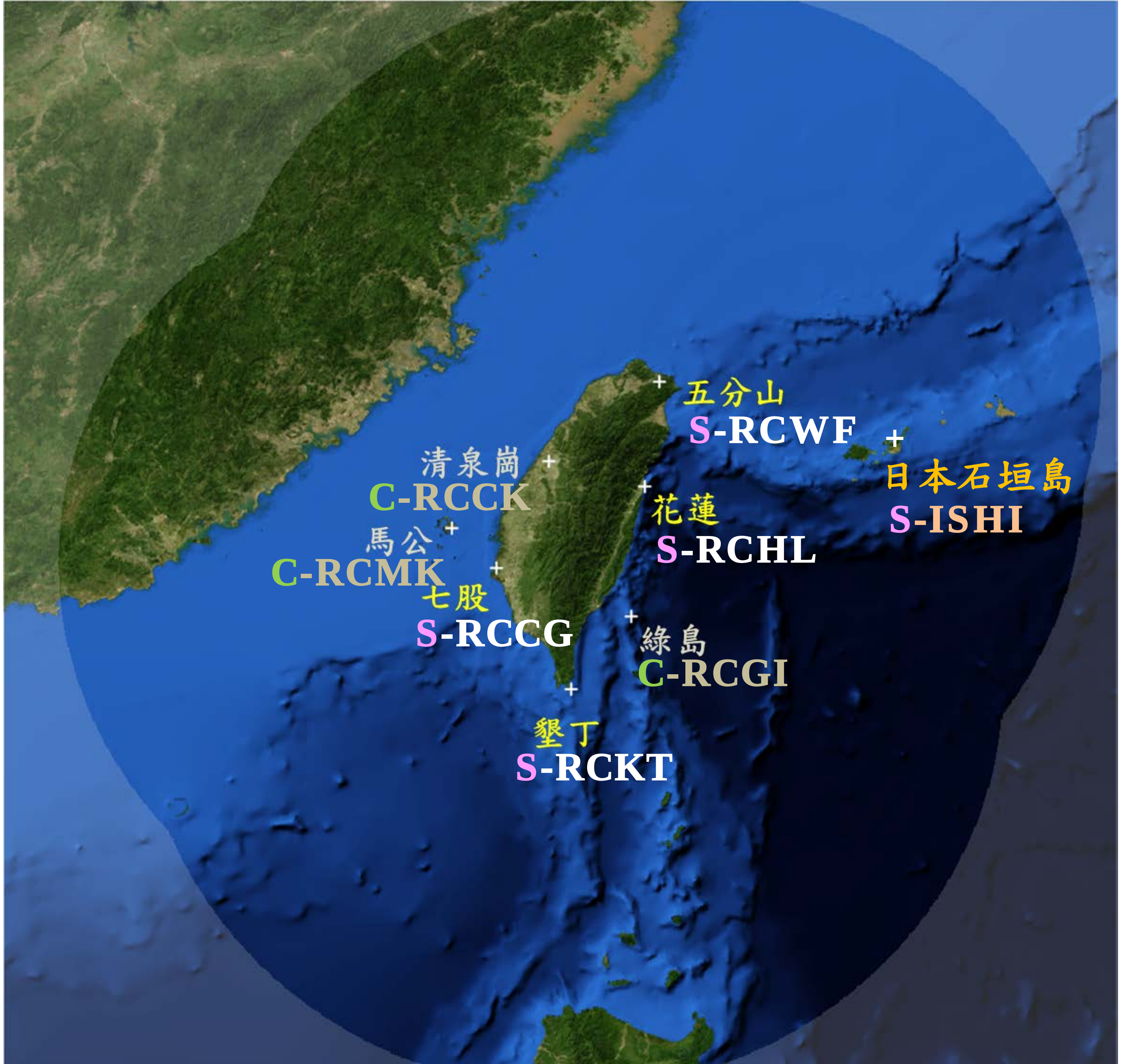
Be operational in 2016



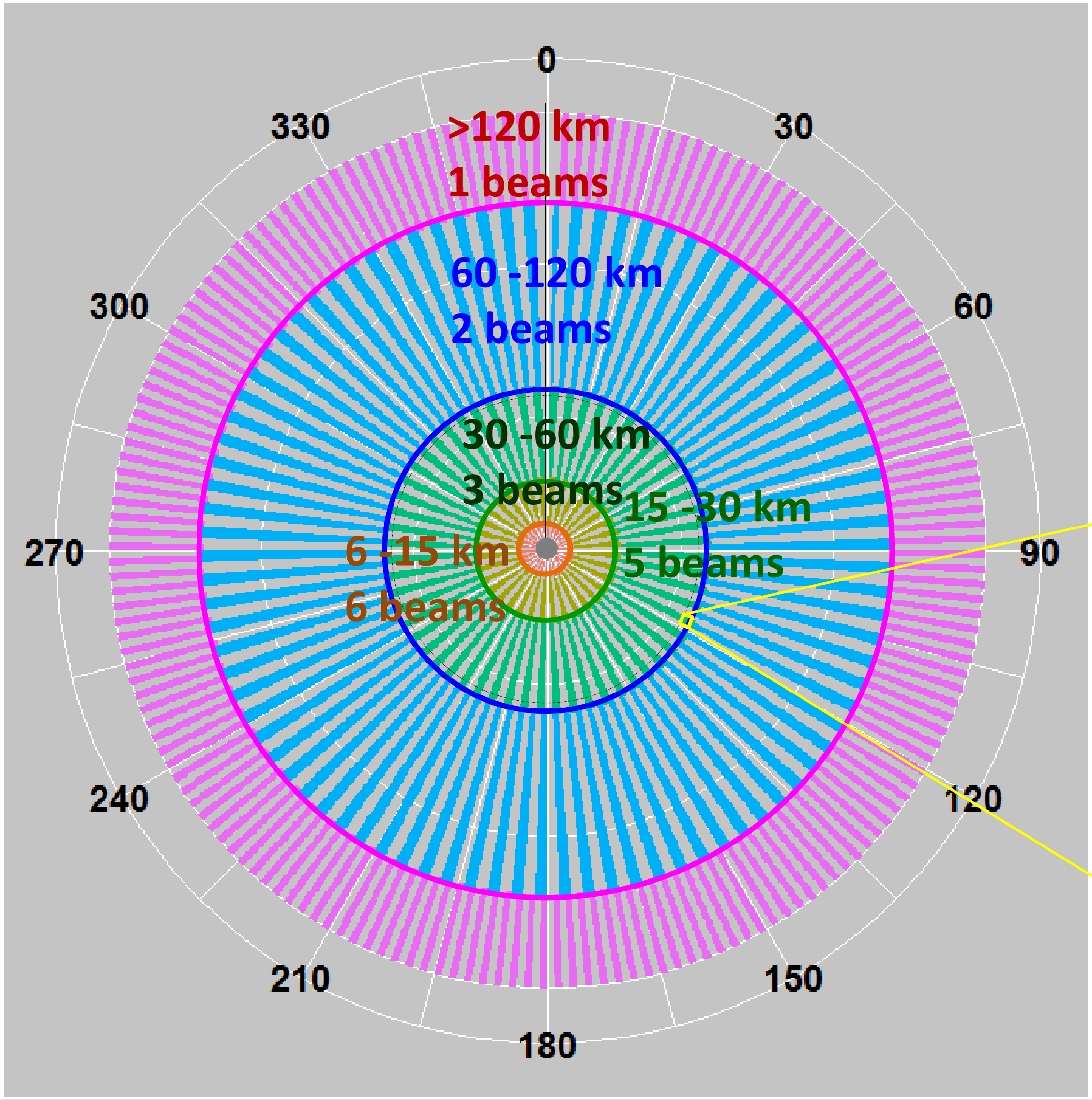
Realtime, **hourly** updated system extended to 12-hr forecast

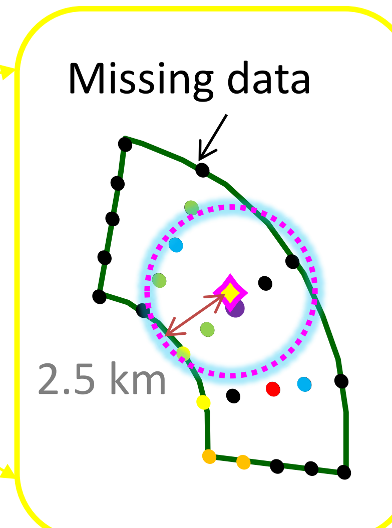
Convective scale EPS




五分山
S-RCWF
清泉崗
C-RCCK
日本石垣島
S-ISHI
花蓮
S-RCHL
馬公
C-RCMK
七股
S-RCCG
綠島
C-RCGI
墾丁
S-RCKT

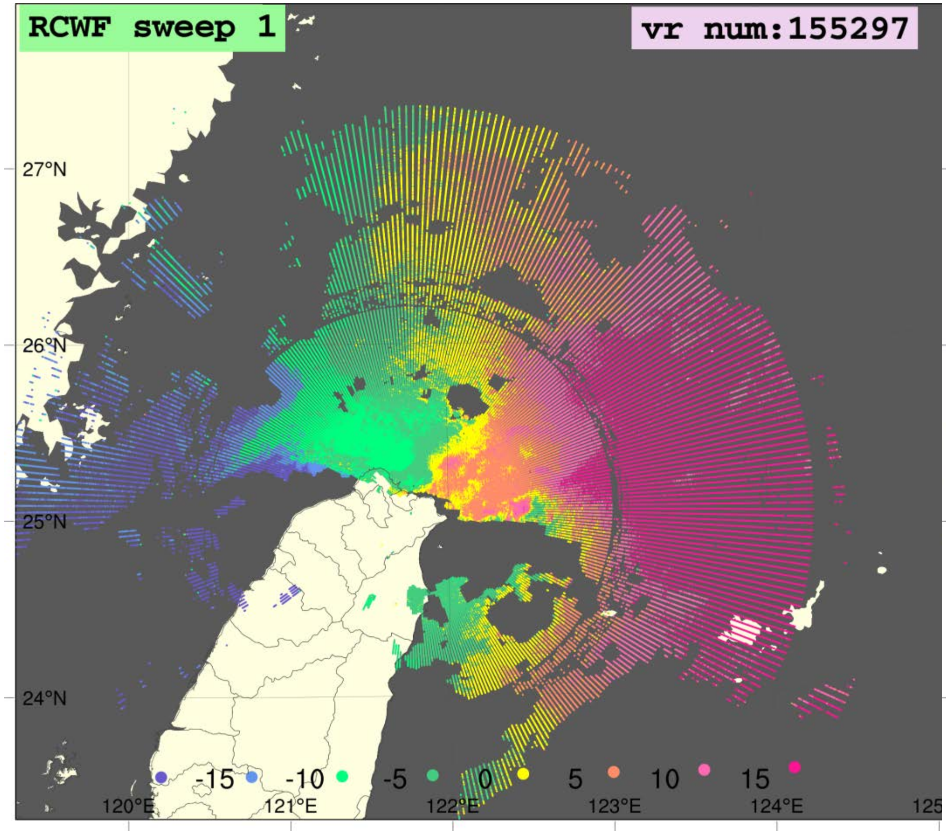
Radar preprocess: Radial velocity

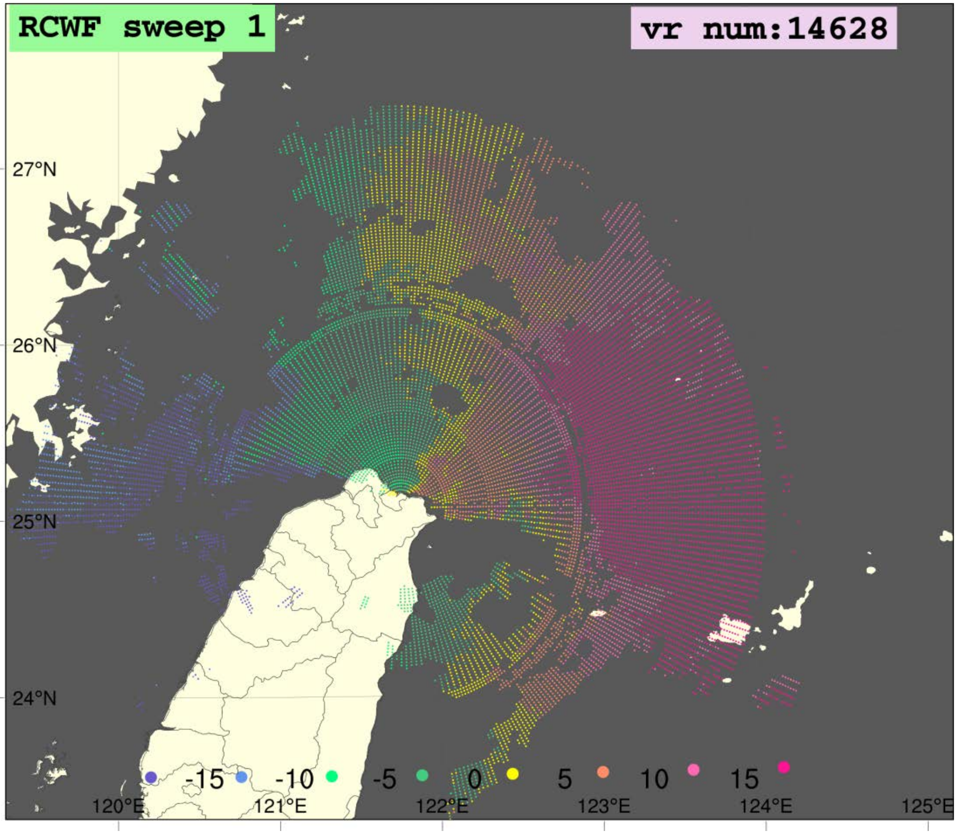




Thinning the radial winds along the azimuthal and radial direction at PPI
Roughly comparable to the model (2-km)

Radar preprocess: Radial velocity



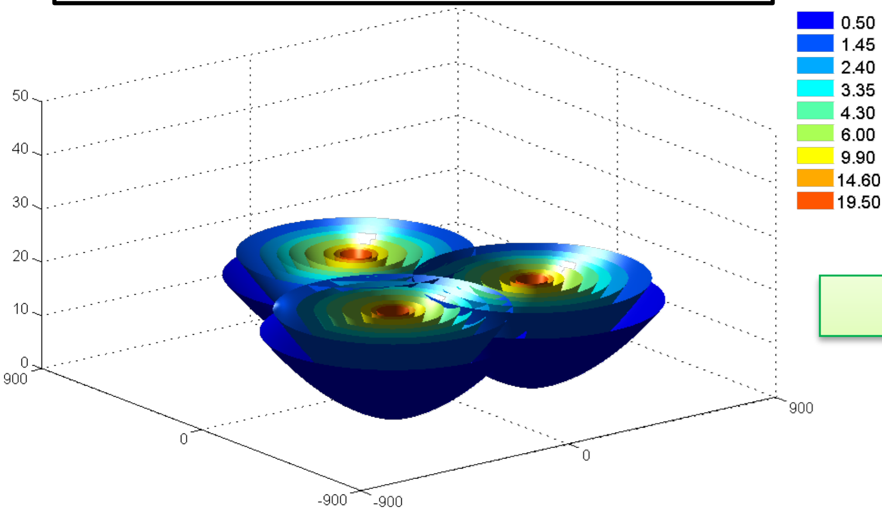


Before thinning:
Obs num: 155,297

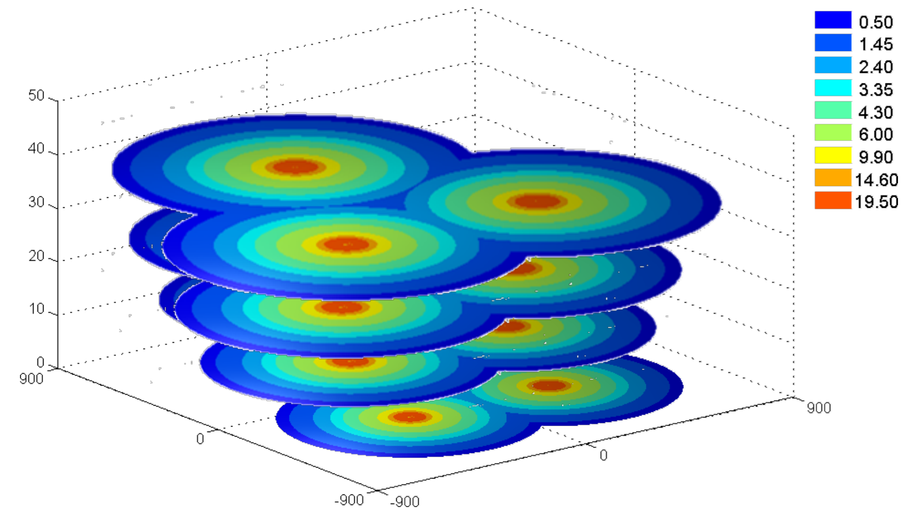
After thinning
Obs num: 14,628

Radar preprocess: Reflectivity

multi-radar volume scans

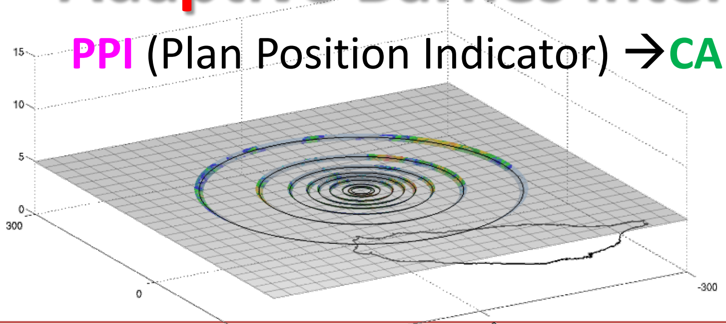


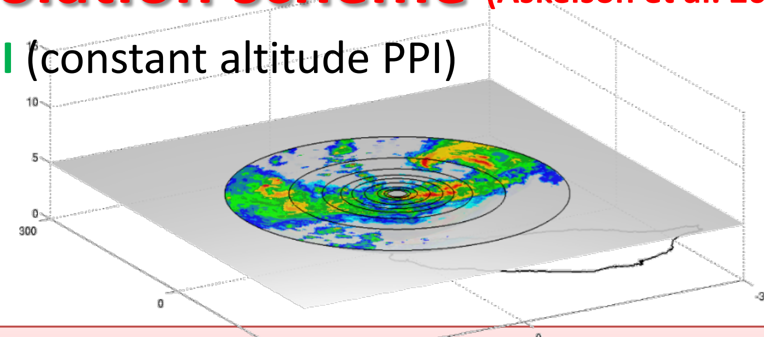
3D mosaic CV



Adaptive Barnes interpolation scheme (Askelson et al. 2000)

PPI (Plan Position Indicator) →CAPPI (constant altitude PPI)





Thinning and compositing the multiple radar reflectivity to the 3D-MOSAIC at

- **the model grid (2-km) in horizontal**
- **250 m in the interval**

- By Wei Ting

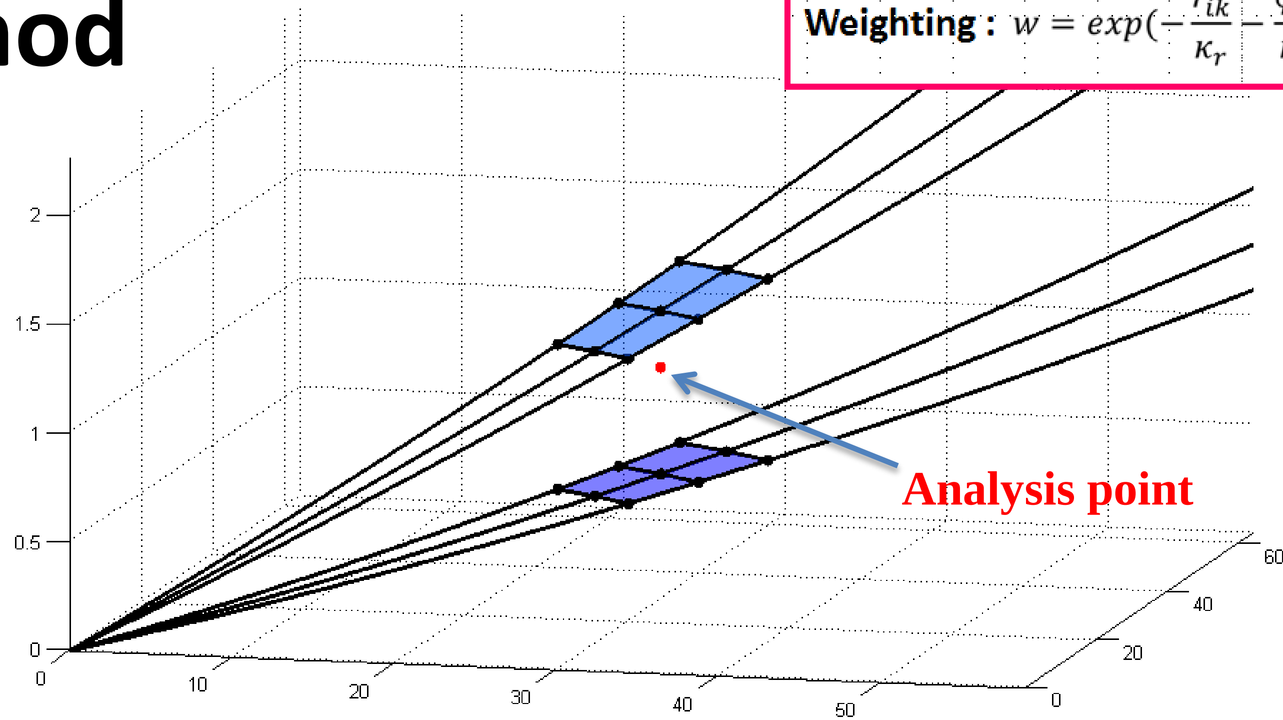
Radar preprocess: Reflectivity

Barnes Method : $f_a(i) = \frac{\sum w(k) \cdot f_o(k)}{\sum w(k)}$

Weighting : $w = exp(-\frac{r_{ik}^2}{\kappa_r} - \frac{\phi_{ik}^2}{\kappa_\phi} - \frac{\theta_{ik}^2}{\kappa_\theta})$

$\kappa_r = 0.336$
$\kappa_\phi = 0.336$
$\kappa_\theta = 0.336$

Method

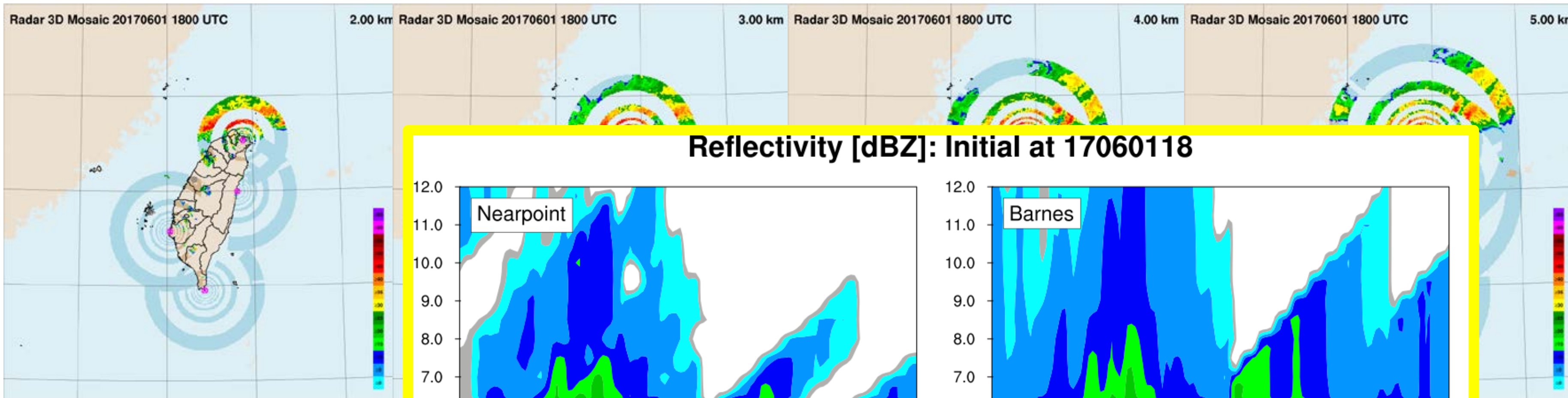


- **Use the nearest 18 data points to interpolate to Cartesian grid.**
- **Missing value(not interpolate):**
  1. **Lower than 0° or higher that last elevation angle.**
  2. **Useful data are less than 6 (33%).**

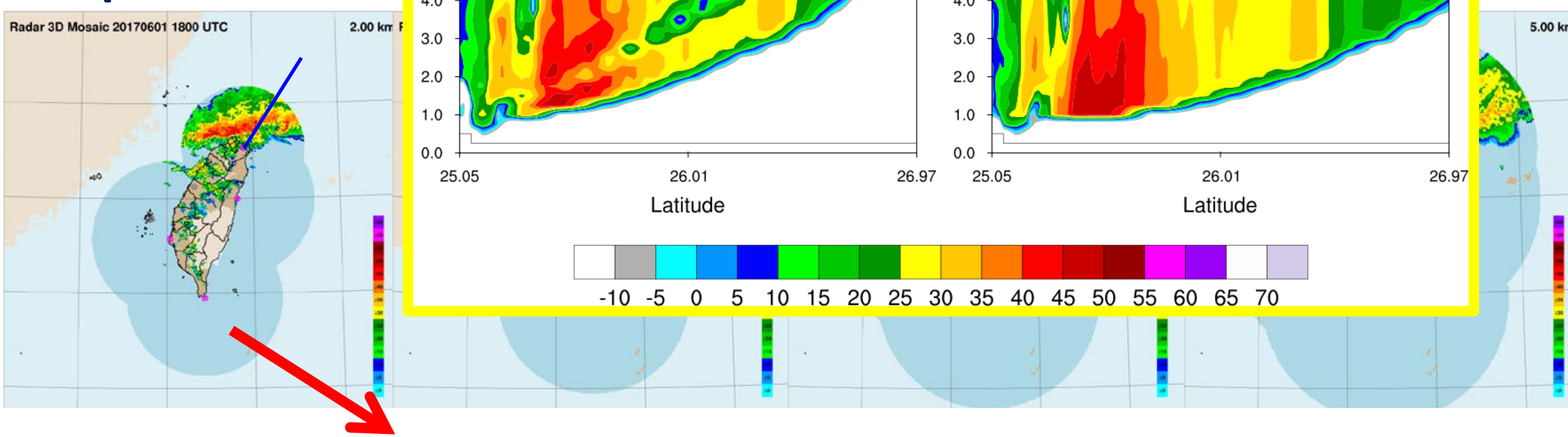
- By Wei Ting

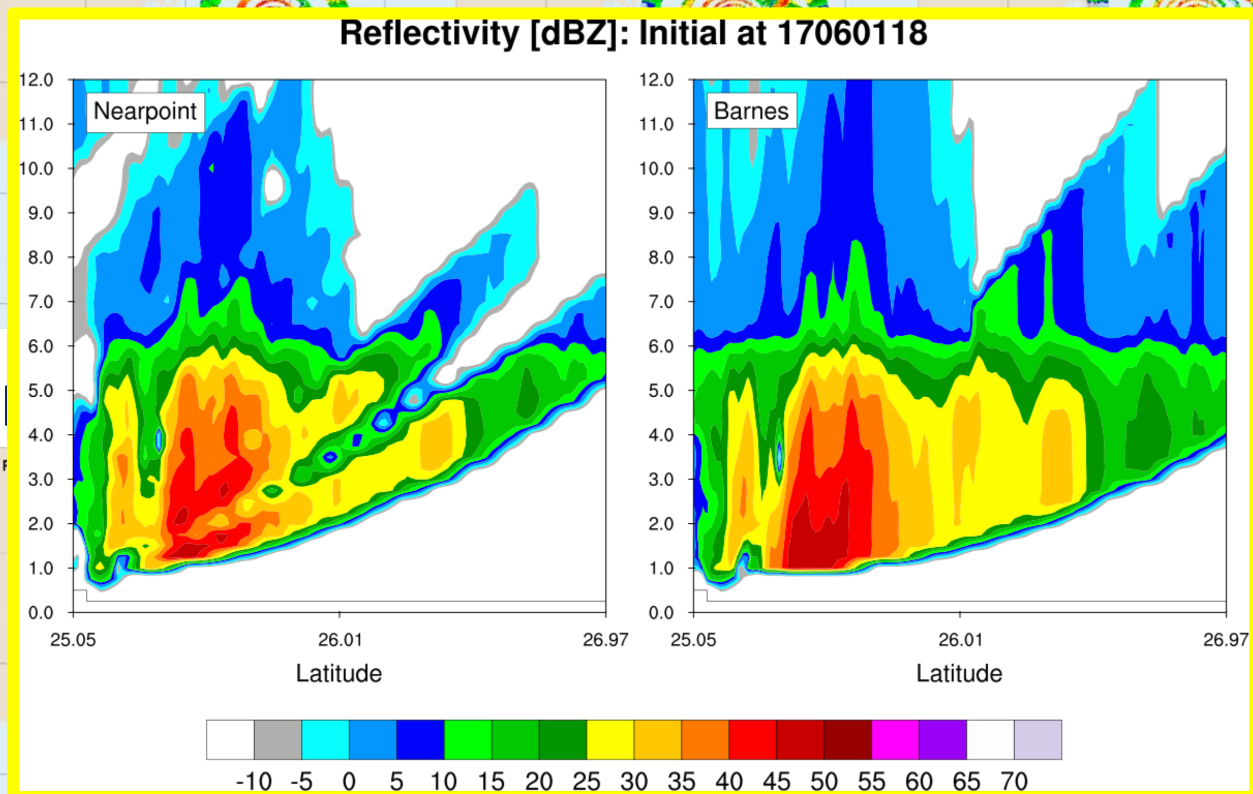
Radar preprocess: Reflectivity

Near point



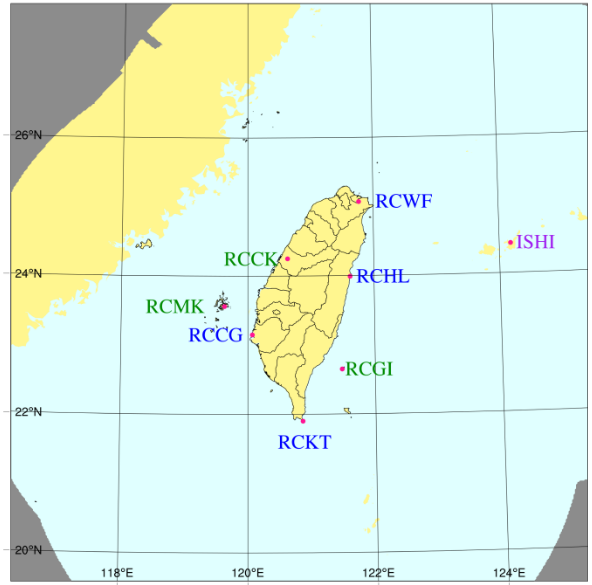
Adaptive Barnes





Use of the “No rain” observation

Model configuration



grid points : 451*451*52
Horizontal resolution : 2km

Radar DA methods

u/v momentum control variables : cv_options = 7 u-, v-wind, temperature, ps and pseudo relative humidity

Microphysics control variables : cloud_cv_options = 3 Wang et al., 2013a

BE of regular variables are from gen_be; cloud variables hard coded

Observation operators

$$V_r = u\sin\phi\cos\mu + v\cos\phi\sin\mu + w\sin\mu$$

μ is the elevation angle and ϕ is the azimuth angle of radar beams

$$Z_e = \begin{cases} Z(q_r) & T_b > 5°C \\ Z(q_s) + Z(q_h) & T_b < -5°C \\ \alpha Z(q_r) + (1-\alpha)[Z(q_s) + Z(q_h)] & -5°C < T_b < 5°C \end{cases}$$

$$Z_{dB} = 10\log_{10} Z_e = 10\log_{10}(Z(q_r) + Z(q_s) + Z(q_h))$$

$$Z(q_r) = 3.63\times10^9(\rho q_r)^{1.75}$$

$$Z(q_s) = 9.80\times10^8(\rho q_s)^{1.75}, \ \mathrm{T} < 0°\mathrm{C}$$

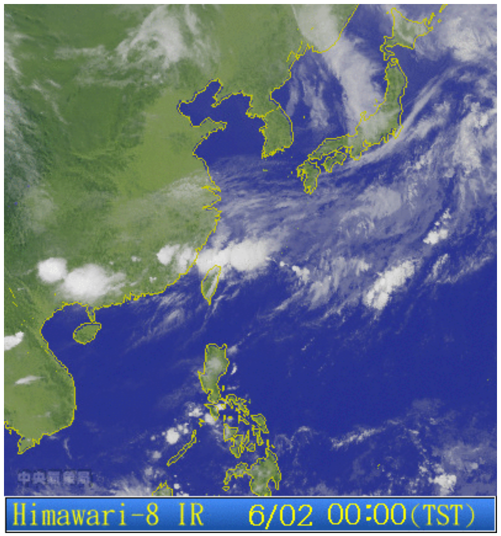
$$Z(q_s) = 4.26\times10^{11}(\rho q_s)^{1.75}, \ \mathrm{T} > 0°\mathrm{C}$$

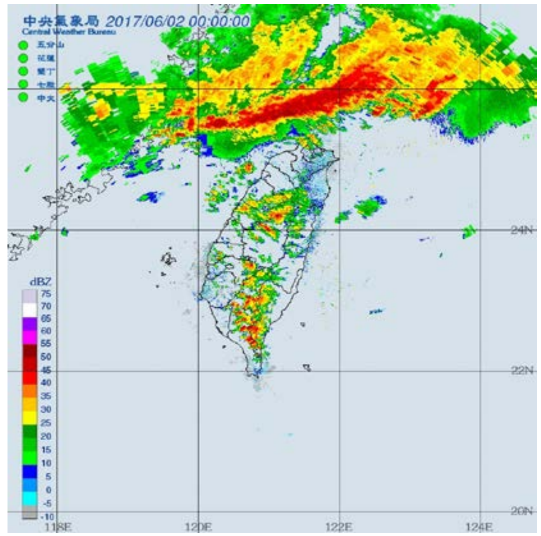
$$Z(q_h) = 4.33\times10^{10}(\rho q_h)^{1.75}$$

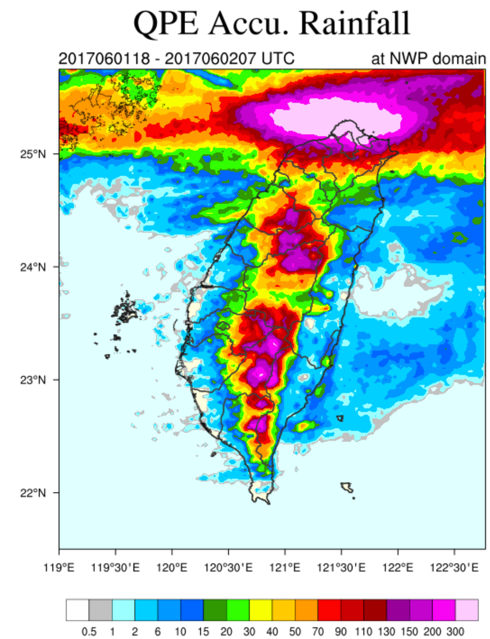
Gao and Stensrud (2012)

Case 1 ：Severe frontal rainband

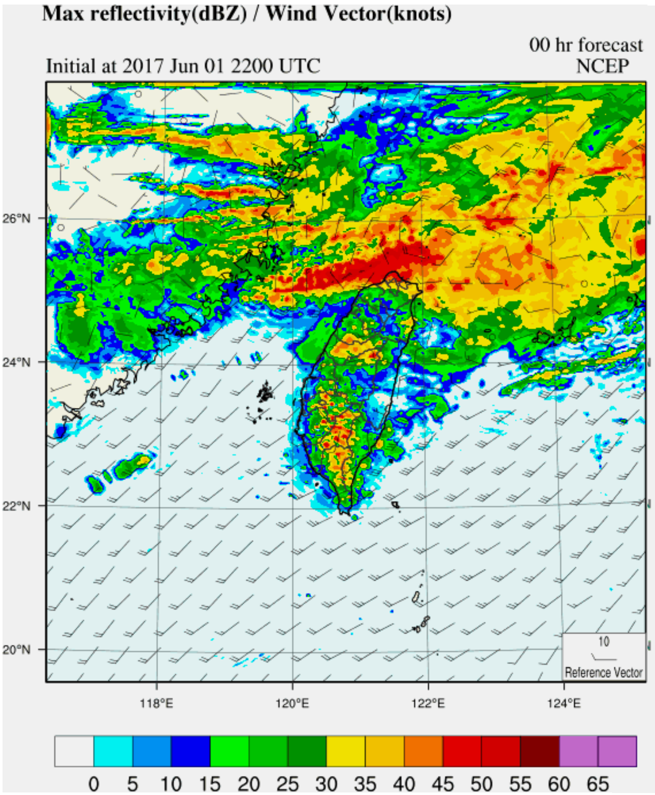
- **Period：170602 00 LST - 170602 15 LST**



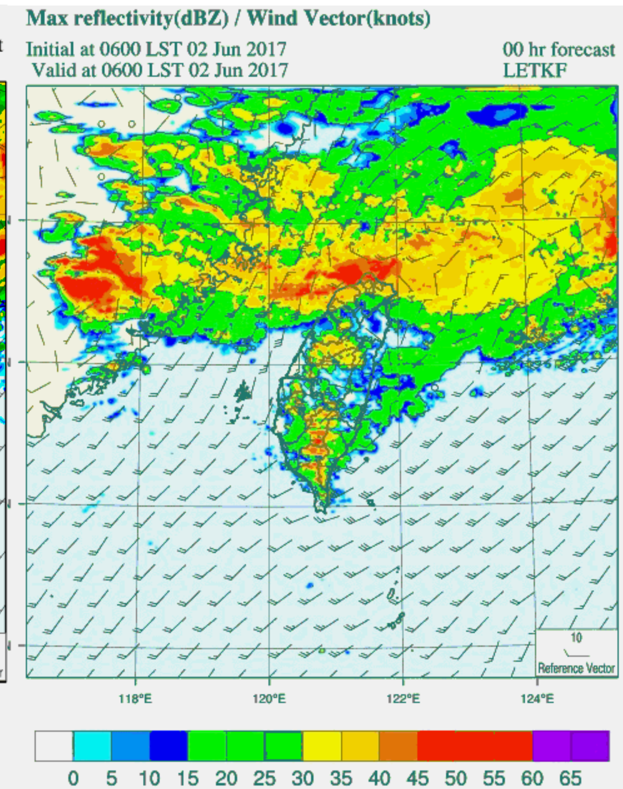




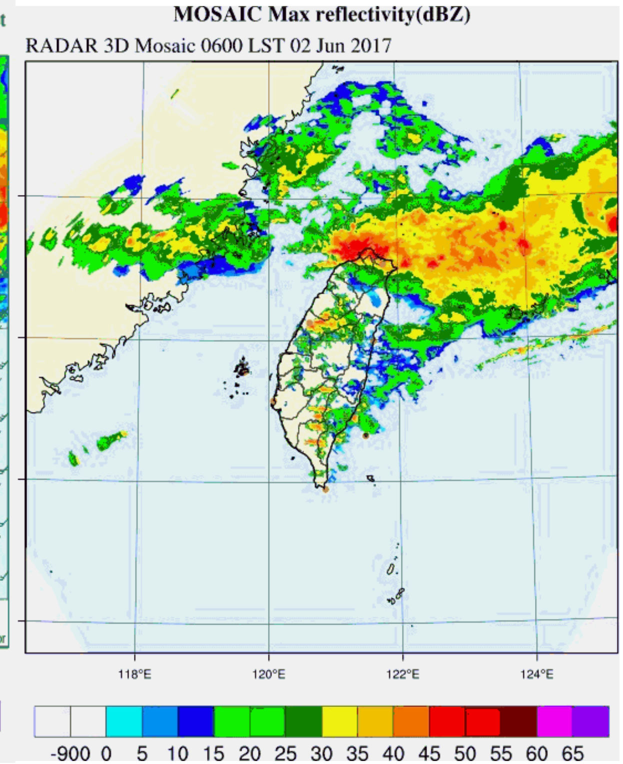
Case 1 ：Severe frontal rainband



3DVAR radar DA



LETKF radar DA



Observation

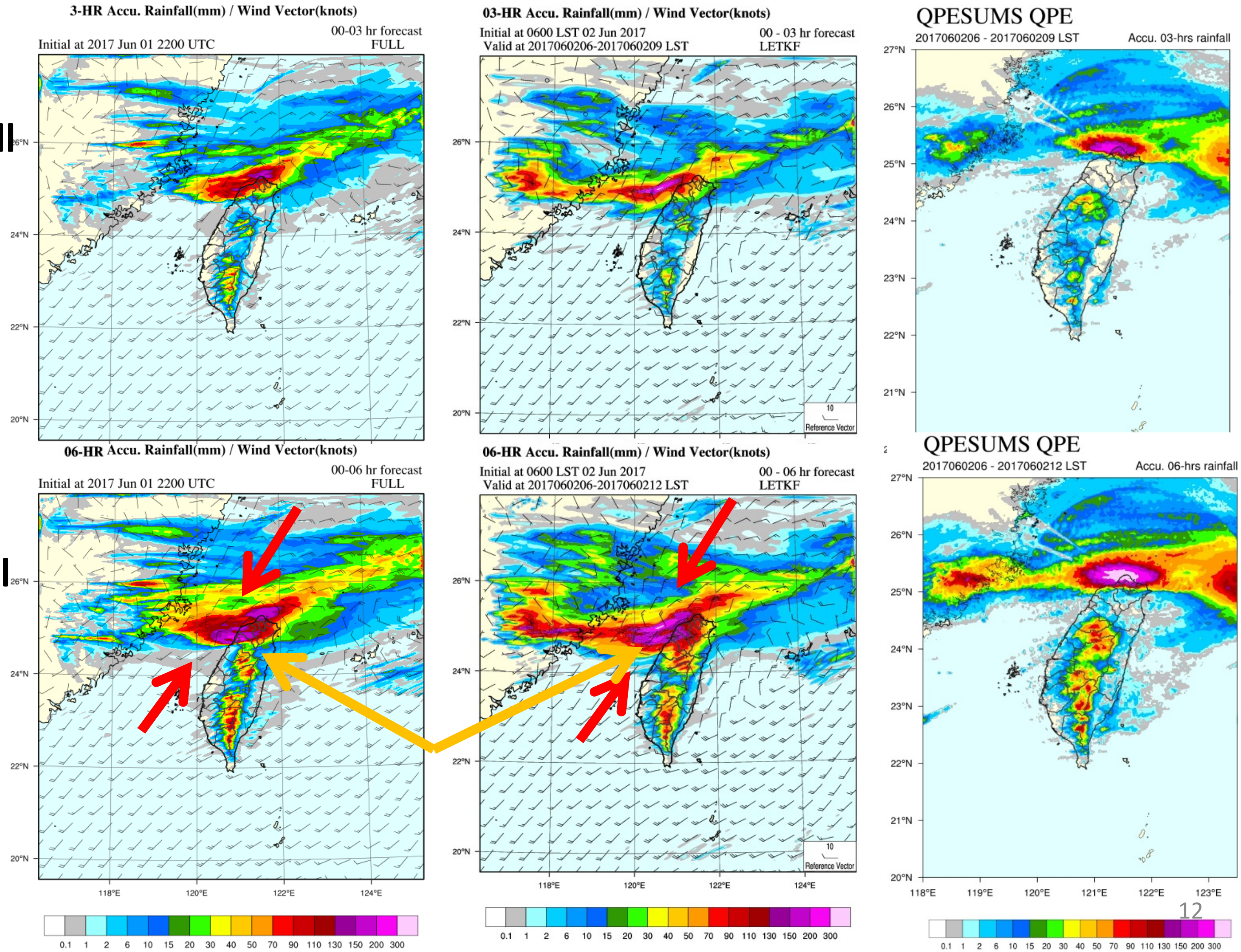
A slightly phase advance for the frontal position

Case 1 ：Severe frontal rainband

3DVAR radar DA | **LETKF radar DA** | **Observation**

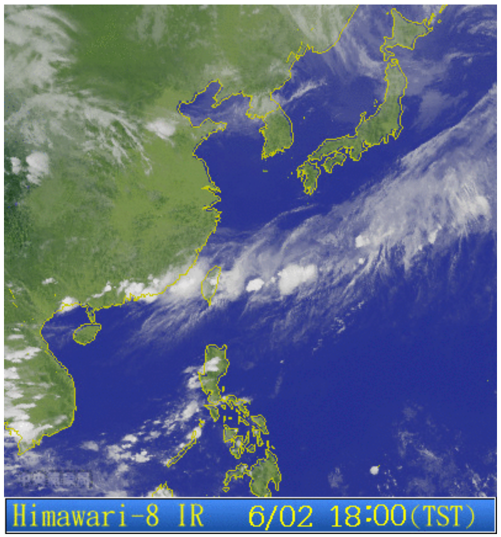
0-3-hr accu. rainfall

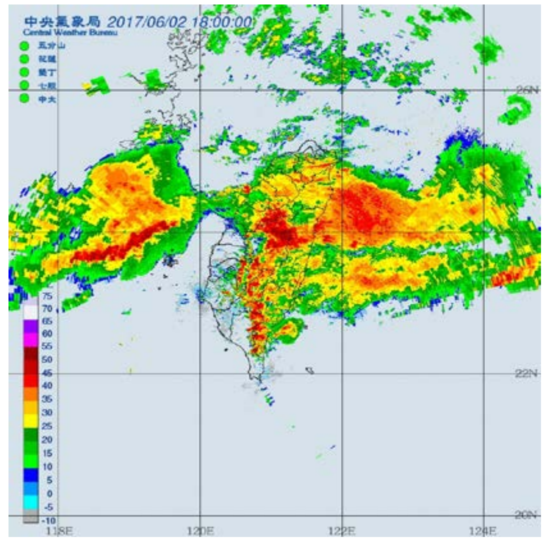
0-6-hr accu. rainfall

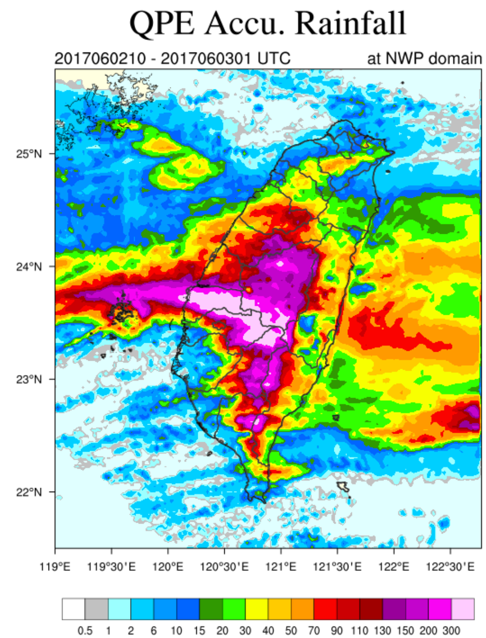


Case 2 ：MCS

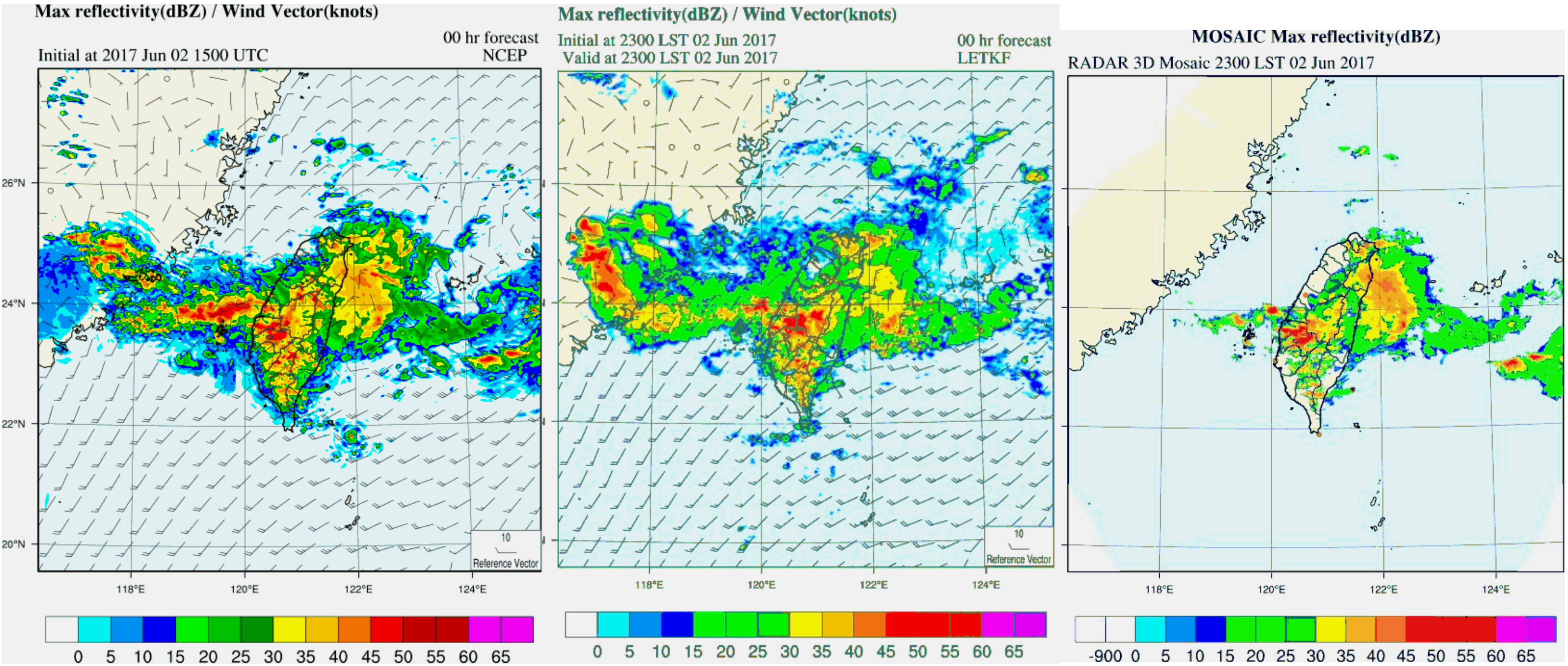
- Period：170602 18 LST - 170603 09 LST







Case 2 ： MCS



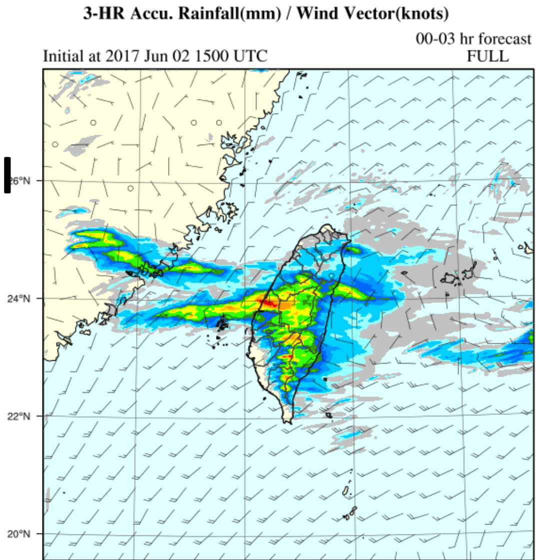
3DVAR radar DA | LETKF radar DA | Observation

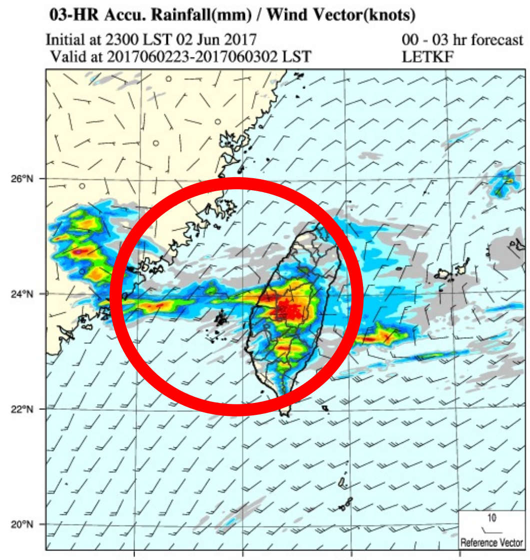
Very challenge to predict the convective activities at the exact time and location

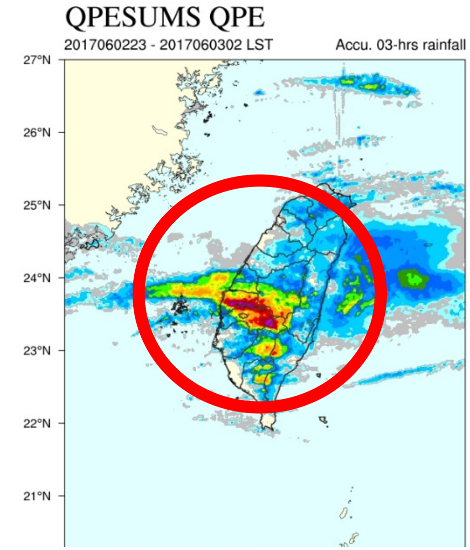
Case 2 ：MCS

	3DVAR radar DA	LETKF radar DA	Observation

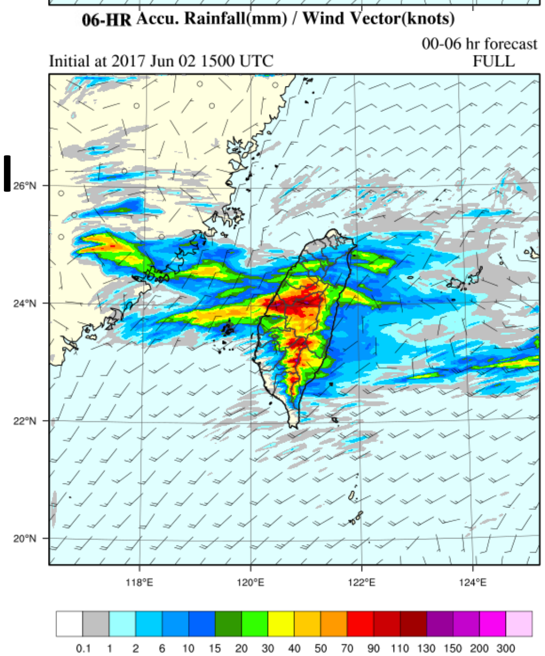
0-3-hr accu. rainfall

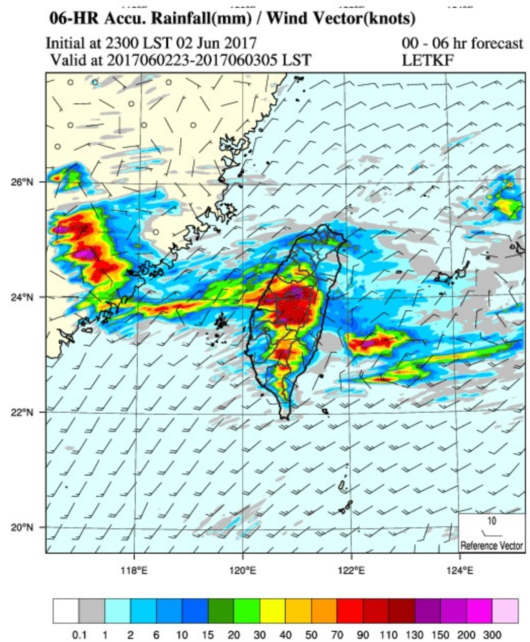


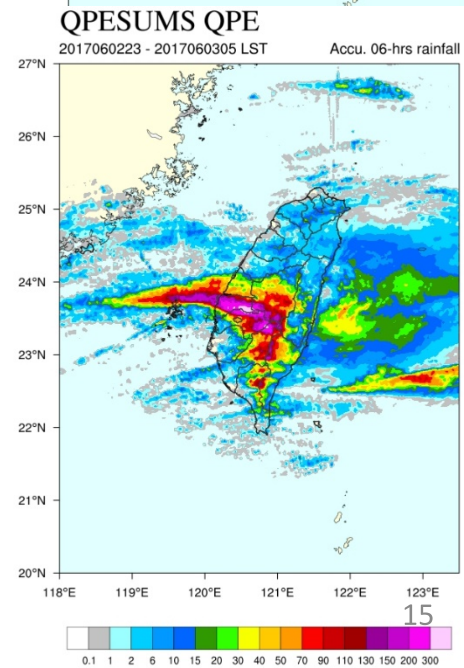




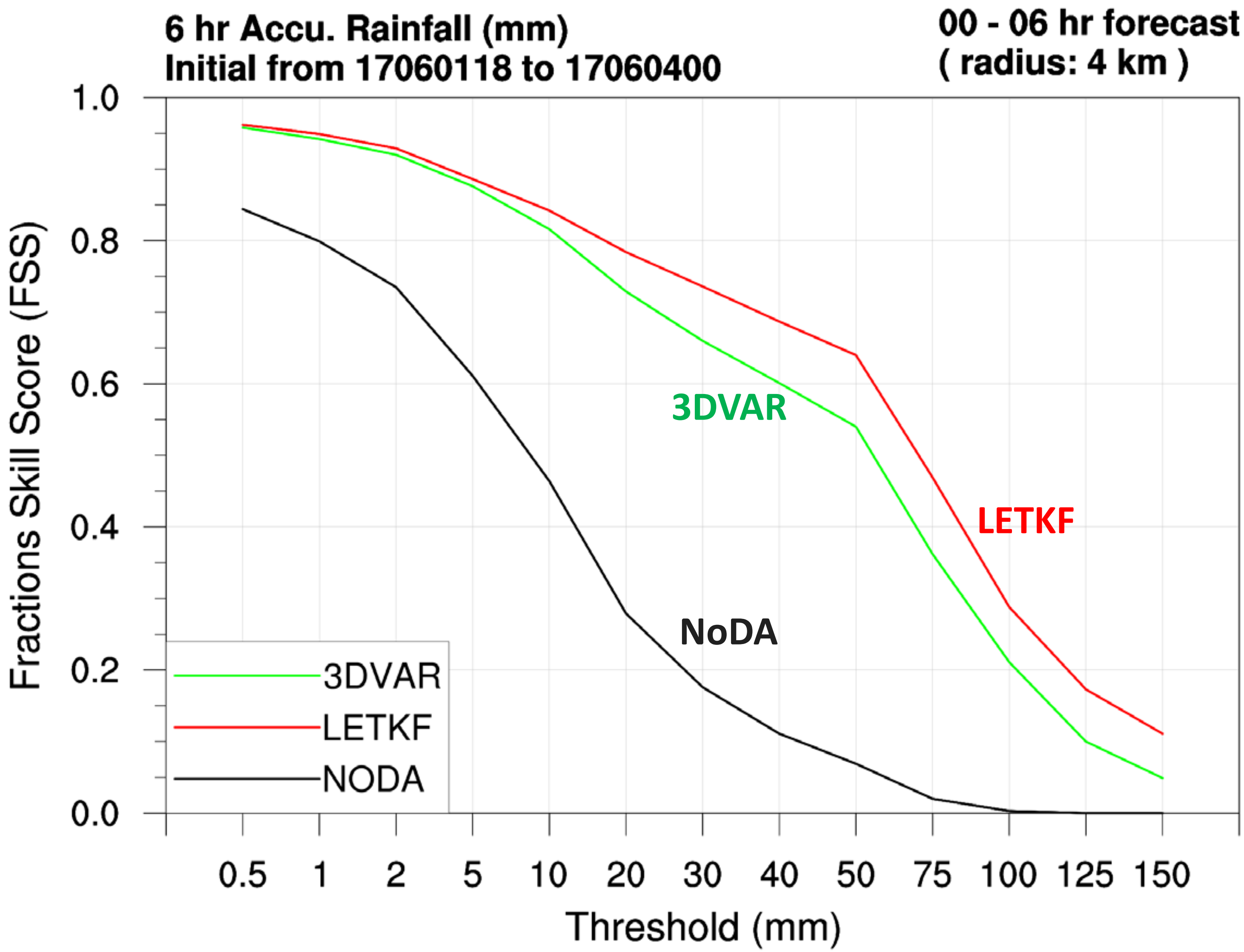
0-6-hr accu. rainfall







FSS SCORE



54 cases for the Mei-Yu frontal rainband system in early June 2017

Summary

- **Two Radar Data Assimilation systems are functional in CWB**
  - **3DVAR system in operation**
  - **LETKF system in a realtime Testbed**
- **LETKF system is slightly better than the 3DVAR system**
  - **Hybrid 3DEnVAR is the next mileage to improve deterministic radar DA system**
- **The Radar QC and Pre-process is critical for the success of the radar data assimilation**
  - **More complete radar observation coverage is of most important**