

# 物件基礎診斷校驗技術於中央 氣象局區域模式定量降水預報 能力之初步評估結果

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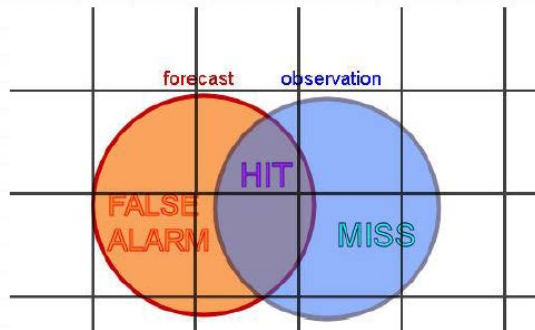
中央氣象局

*Acknowledgments:* John Halley Gotway, Tara Jensen

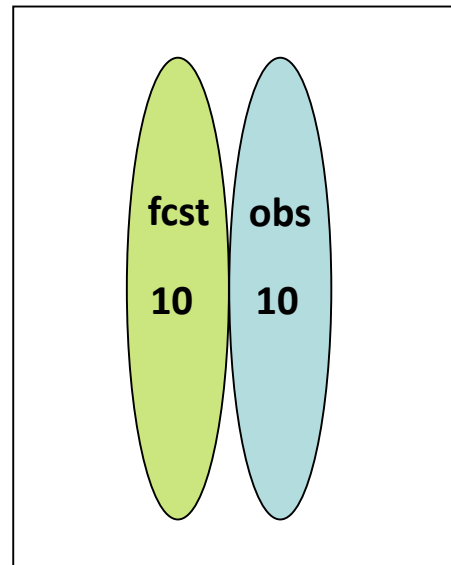
# Verification

- Traditional verification requires an exact match between forecasts and observations at every grid point

Which is better?



double penalty

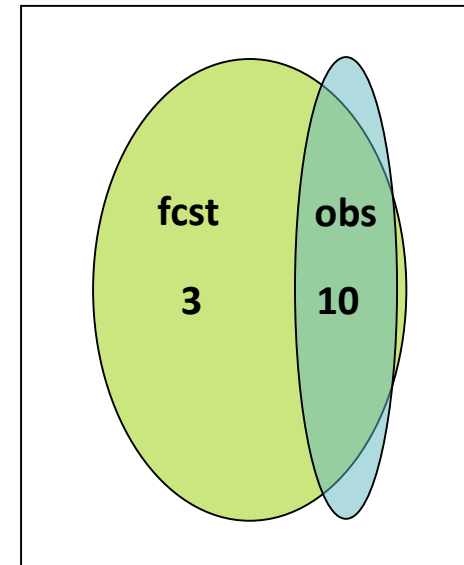


**Hi res forecast**

POD = 0

FAR = 1

TS = 0



**Low res forecast**

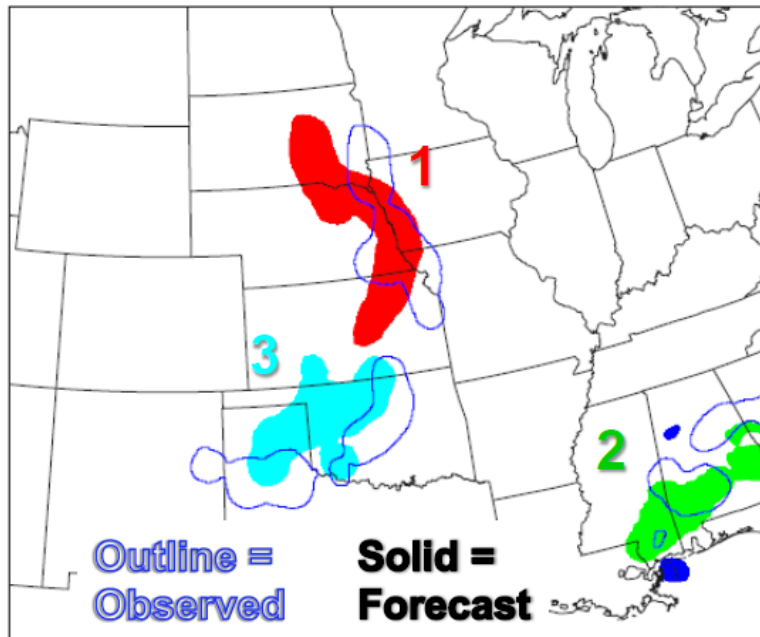
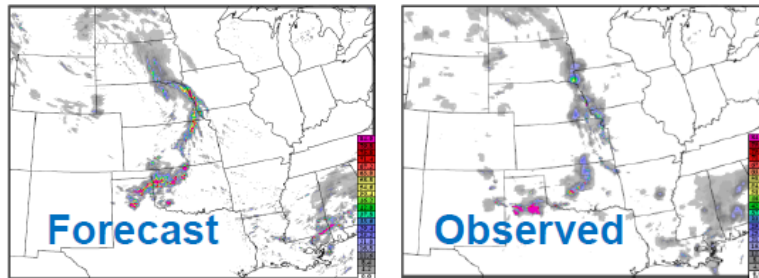
POD ~ 1

FAR ~ 0.7

TS ~ 0.3

# Spatial verification

24h forecast of 1h rainfall on 1 June 2005



WRF ARW-2 Objects with Stage  
II Objects overlaid

( Courtesy of Barbara G. Brown )

- **Area ratios**

- (1) 1.3

- (2) 1.2

- (3) 1.1

- **Location errors**

- (1) Too far west

- (2) Too far south

- (3) Too far north

- **Median intensity ratio**

- (1) 1.3

- (2) 0.7

- (3) 1.9

In contrast:

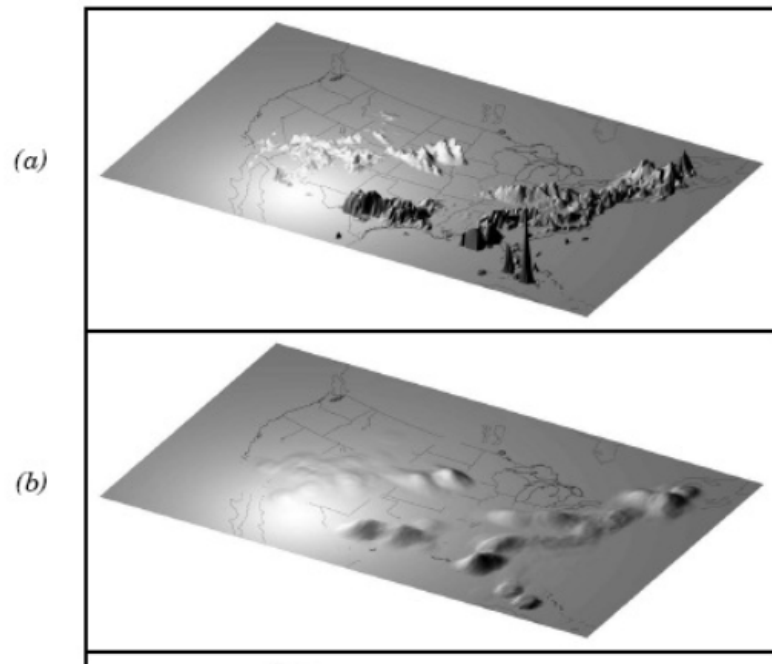
POD = 0.40

FAR = 0.56

TS = 0.27

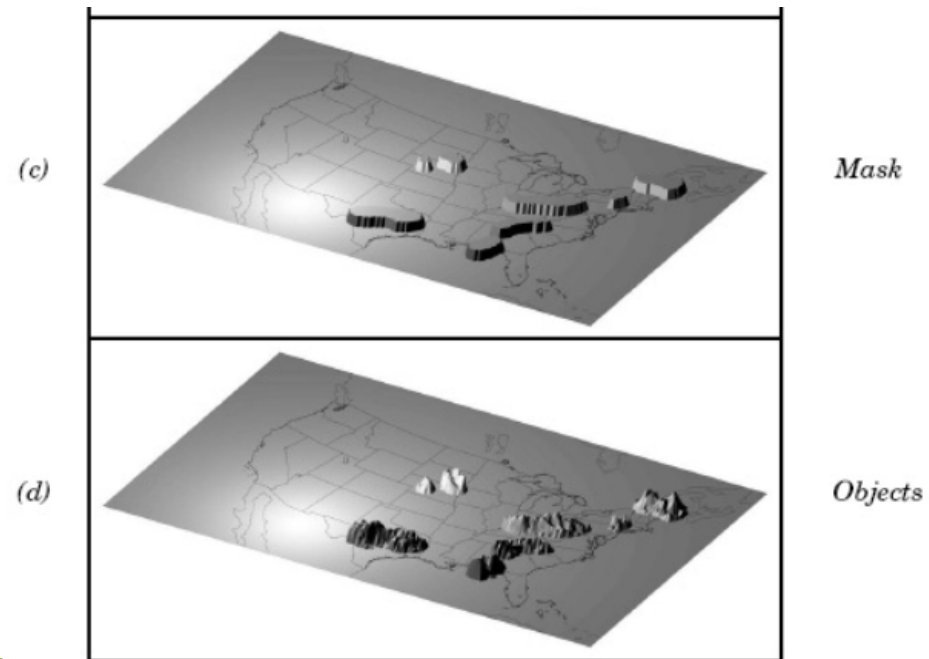
# Method for Object-based Diagnostic Evaluation (MODE)

Davis et al., *MWR*, 2006



*Raw*

*Convolved*



*Mask*

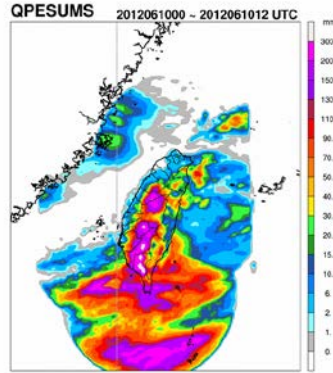
*Objects*

Two parameters:

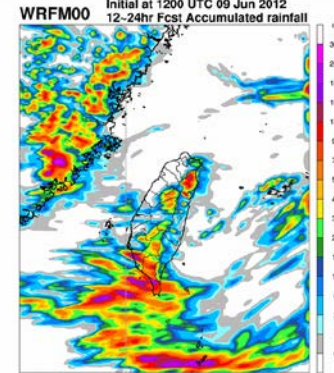
1. Convolution radius ( $R$ ) - Smoothing
2. Threshold ( $T$ )

# MODE applied to TW rain example

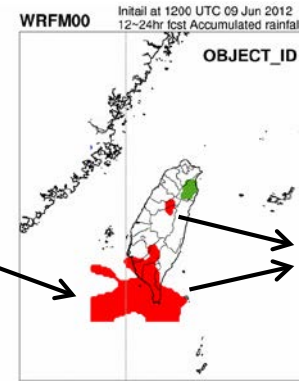
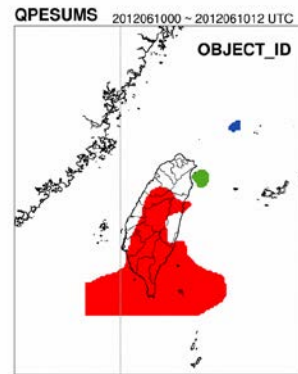
OBS



FCST



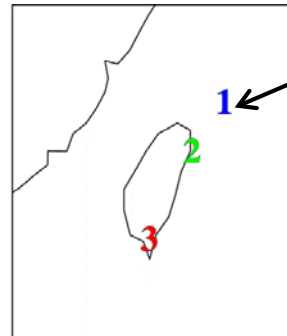
- Matched Object 1
- Matched Object 2
- Unmatched Object



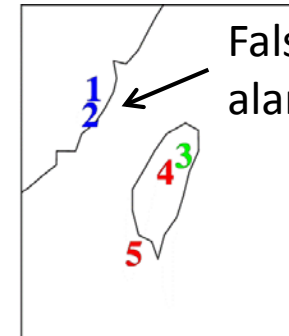
Matching

Merging

Fcst	Obs	Interest
5	3	0.9273
4	3	0.8662
3	2	0.7979



Misses



False alarms

# Data

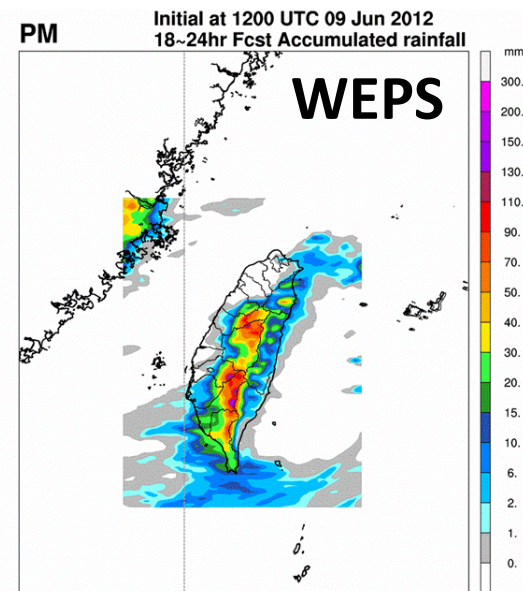
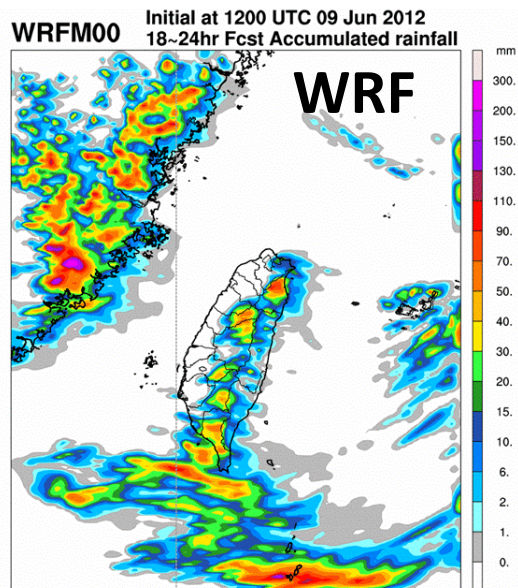
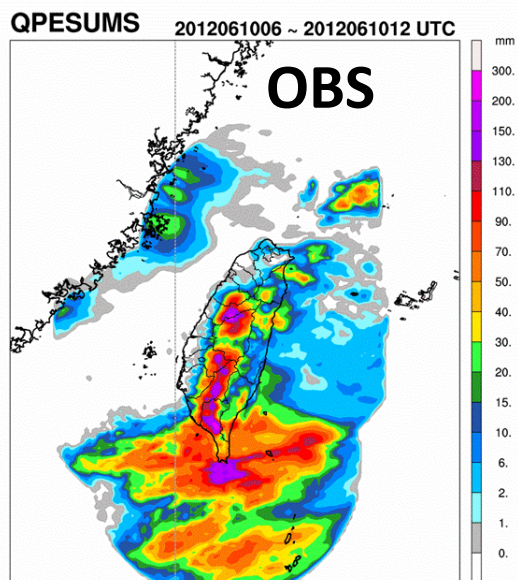
- Model
  - ARW-**WRF** deterministic regional forecast system
  - **WRF**-based **E**nsemble **P**rediction **S**ystem (**WEPS**)
  - Both **5km resolution**
- Observation
  - **Q**uantitative **P**recipitation **E**stimates and **S**egregation **U**sing **M**ultiple **S**ensor (**QPESUMS**)

# Aggregated case

- Comparison of WRF and WEPS deterministic QPF performance using MODE technique.
  - Meiyu case valid time:  
**0600UTC 10 ~ 1800UTC 15 June 2012**
  - **Radius (R) = 5 km**, slightly smoothing.
  - **Thresh (T)  $\geq 30$  mm** for 6hr accumulated rainfall
  - **0~6, 6~12, 12~18, 18~24hr** forecast lead time

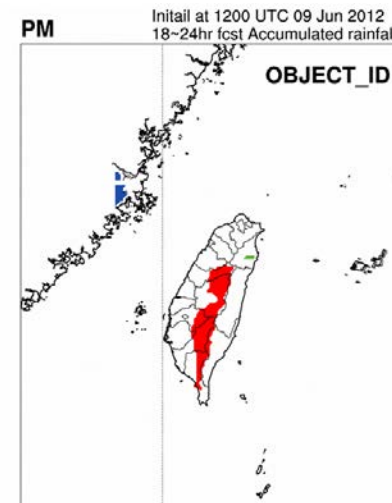
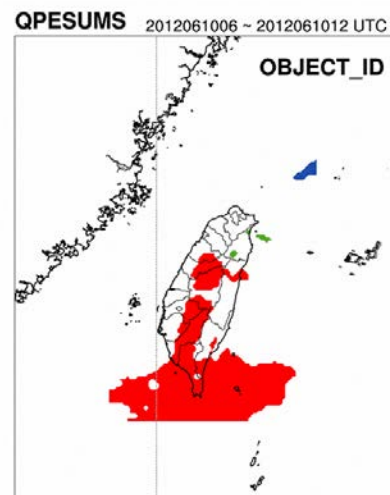
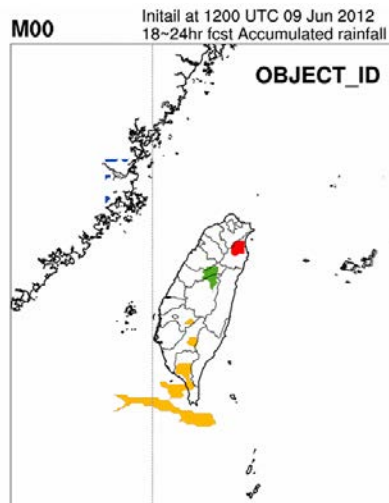
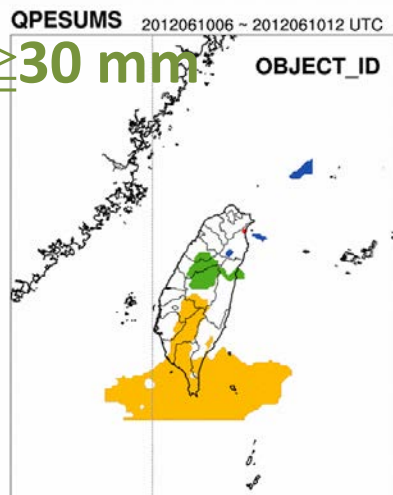


# Valid at 1200UTC 10 Jun 2012, 18~24hr Forecast



R = 5 km

$T \geq 30 \text{ mm}$



**WRF**

**WEPS**



# Simple Object Counts and Areas

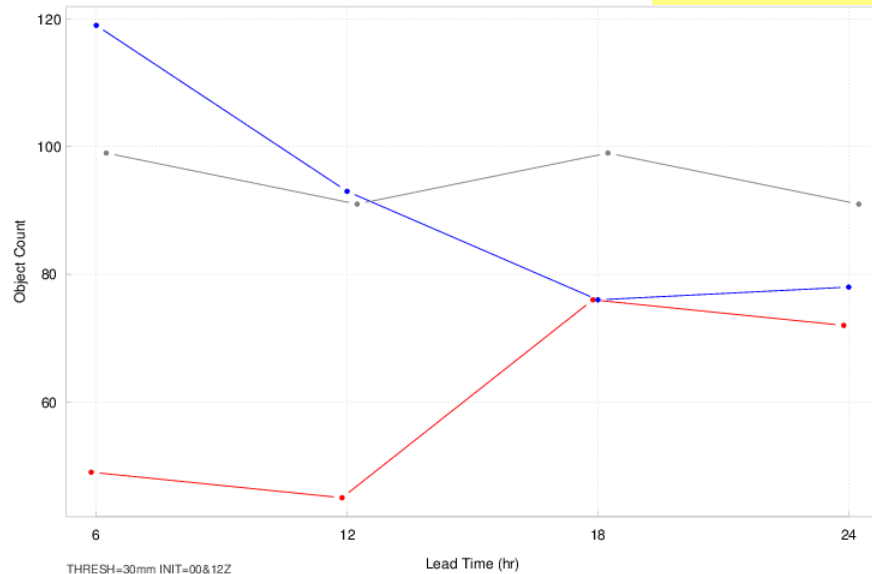
WEPS

WRF

OBS

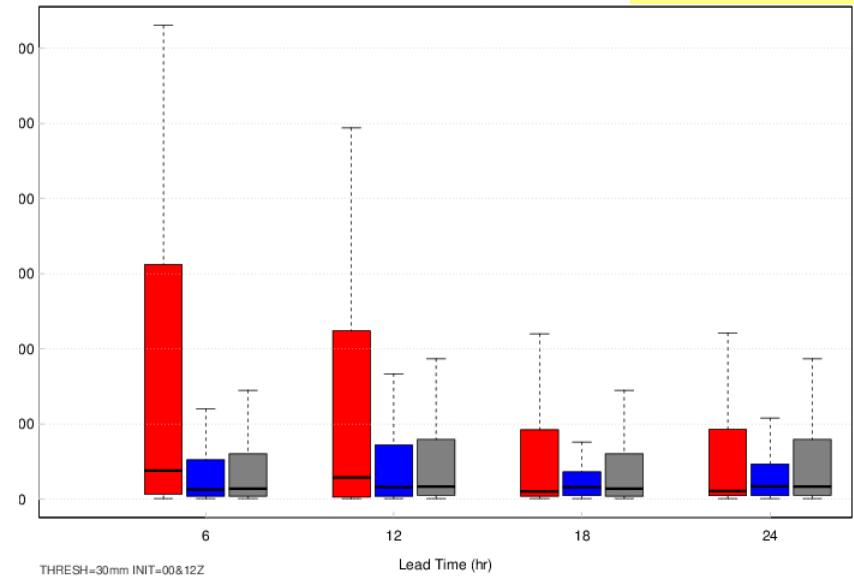
Total Object Counts

Counts



Objects Areas

Areas



**WEPS has smaller total numbers and larger area of objects**

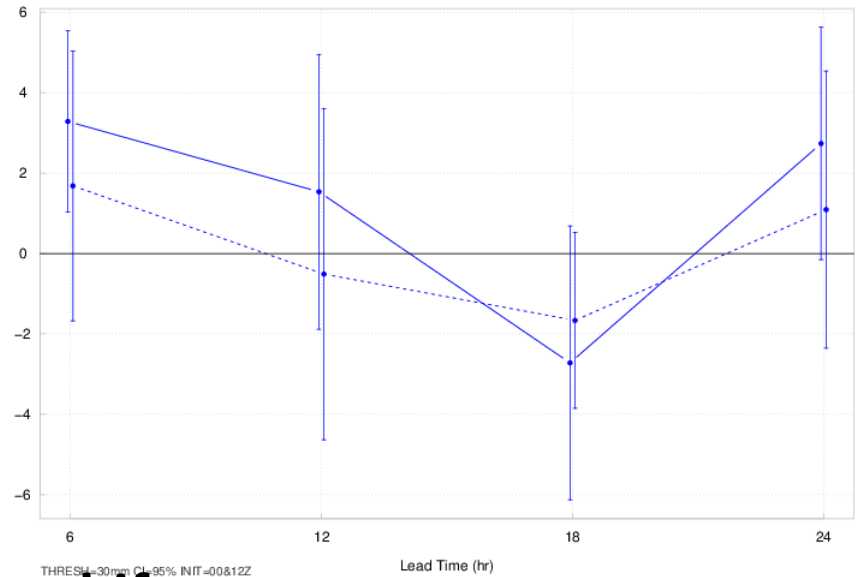
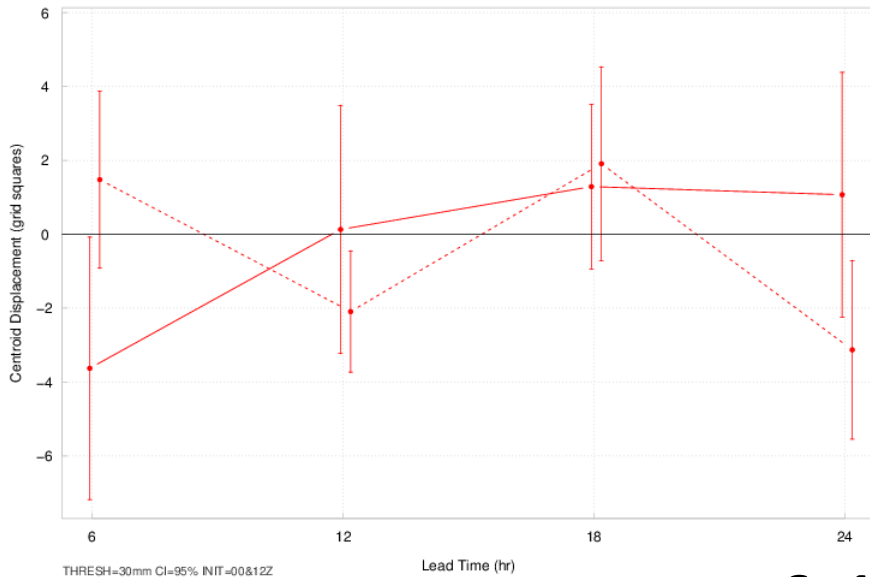
# Matched Objects Centroid Displacement

— WEPS (CENTX)  
 ..... WEPS (CENTY)

— WRF (CENTX)  
 ..... WRF (CENTY)

WEPS Matched Objects Centroid Displacement

WRF Matched Objects Centroid Displacement



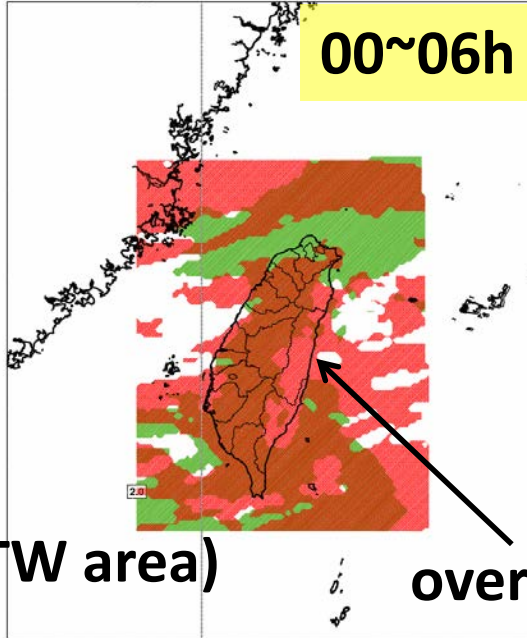
6~18 hr shift

X: westerly -> neutral -> easterly

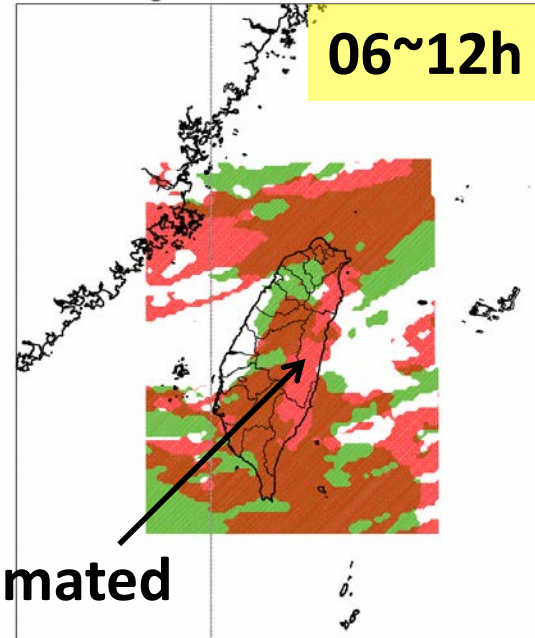
X: easterly -> westerly

Y: northerly -> southerly

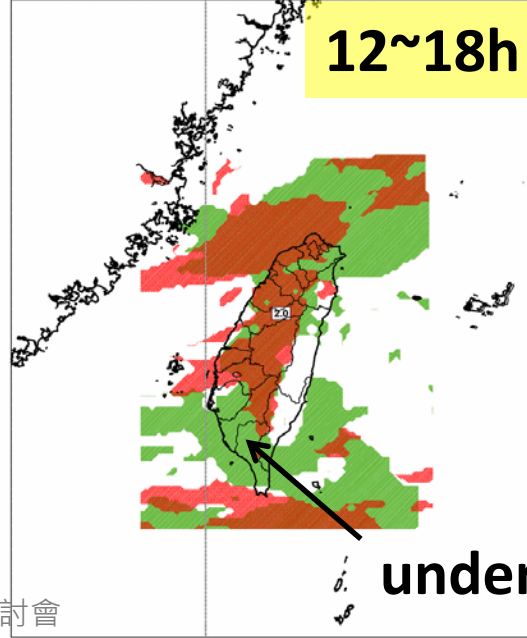
M00 06dtg Initial at 0000 UTC 10 Jun 2012  
00~06hr fcst Accumulated rainfall



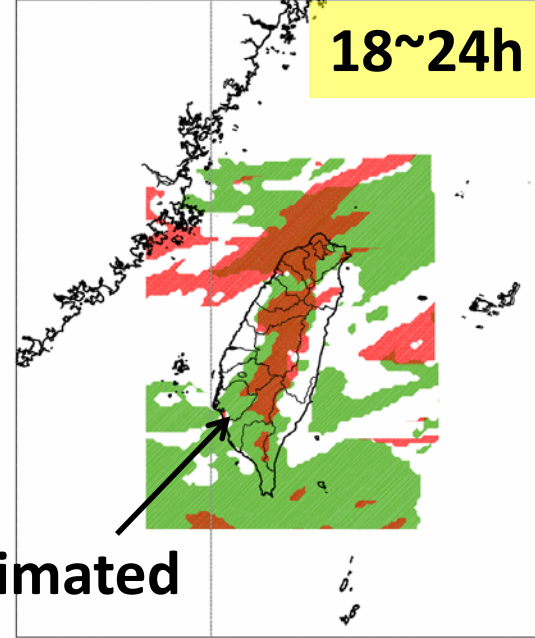
M00 06dtg Initial at 0000 UTC 10 Jun 2012  
06~12hr fcst Accumulated rainfall



M00 06dtg Initial at 0000 UTC 10 Jun 2012  
12~18hr fcst Accumulated rainfall



M00 06dtg Initial at 0000 UTC 10 Jun 2012  
18~24hr fcst Accumulated rainfall



3day WRF Obj's  
3day OBS Obj's

08~20 LST

easterly bias (TW area)

overestimated

20~08 LST

underestimated

# 2012 Meiyu case for 1 month

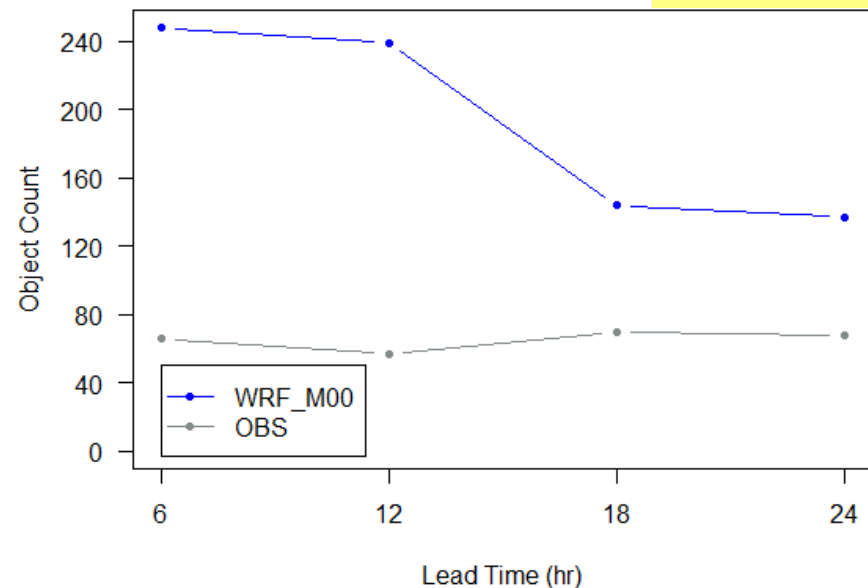
- Evaluate WRF deterministic QPF performance using MODE technique.
  - **0000UTC 20 May~ 1800UTC 20 June 2012,**  
**Initial time = 0000UTC**
  - **Radius (R) = 5 km,** slightly smoothing.
  - **Thresh (T)  $\geq$  30 mm** for 6hr accumulated rainfall
  - **0~6, 6~12, 12~18, 18~24hr** forecast lead time

# Simple Object Counts and Areas

WRF

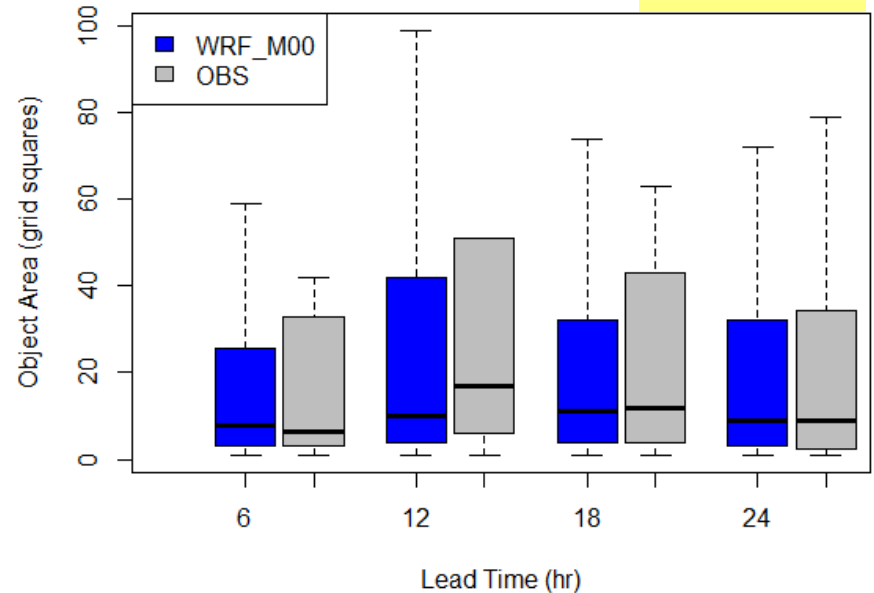
OBS

Total Object Counts **Counts**



**WRF has larger total numbers**

Simple Object Areas **Areas**



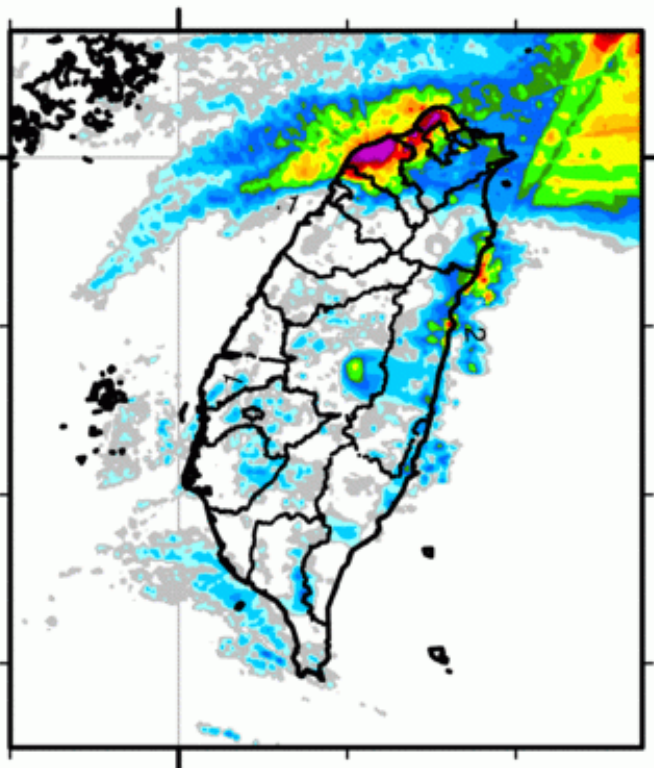
**Median & 25<sup>th</sup> percentile distribution similar**

Initial Time :  
2016.6.1 12 UTC

Accumulated Rainfall : 12~24hr forecast  
2016.6.2 8 LST ~2016.6.2 20 LST

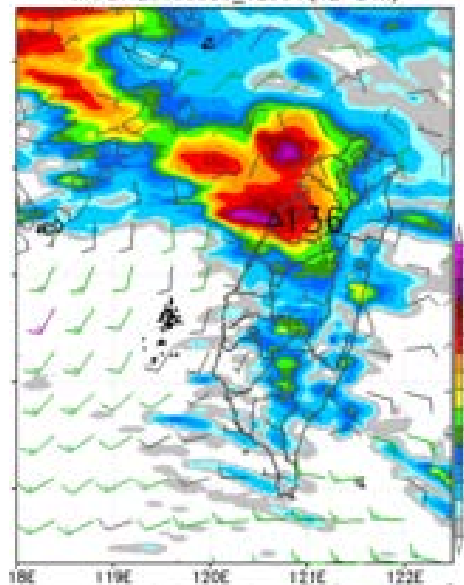
OBS

QPESUMS



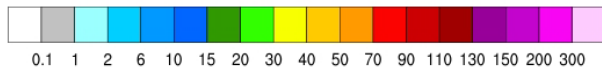
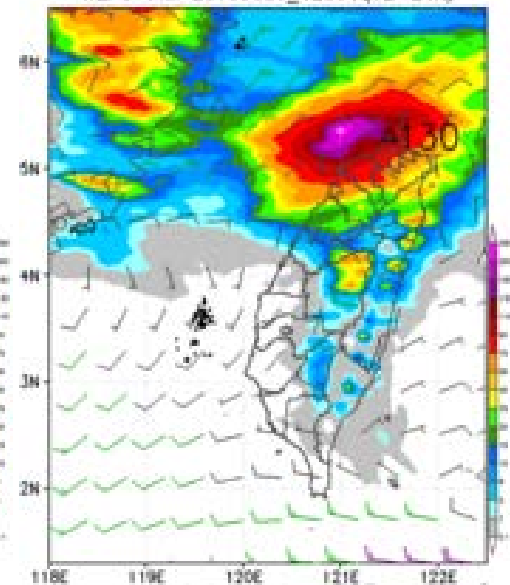
WRFD

WRFD: 20160601\_1200+(12-24h)



WEPS PM

WEPS-PM: 20160601\_1200+(12-24h)





Initial Time :  
2016.6.1 12 UTC

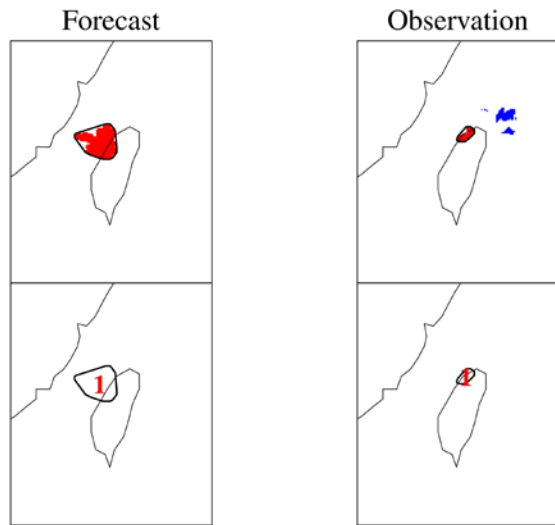
Accumulated Rainfall : 12~24hr forecast  
2016.6.2 8 LST ~2016.6.2 20 LST

$\geq 50$  mm

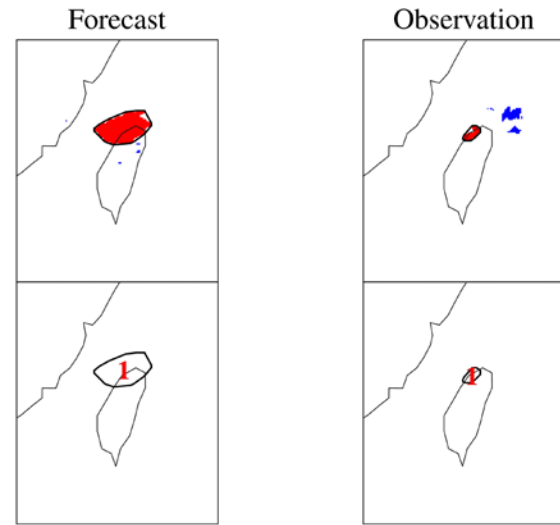
WRFD

WEPS PM

Cluster Object Information



Cluster Object Information



CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR	CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR
1	15.43	52.31	472	69	11	530	519	78.91	77.14	121.54	145.03	0.7939	1	4.35	24.13	640	69	69	640	571	75.83	77.14	131.15	145.03	0.8889

displacement bigger (centroid distance bigger & intersection area smaller)

simulated better (total interest higher)

Initial Time :  
2016.6.1 12 UTC

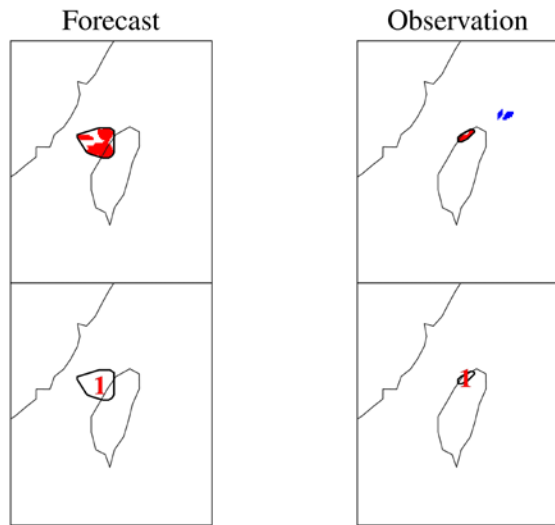
Accumulated Rainfall : 12~24hr forecast  
2016.6.2 8 LST ~2016.6.2 20 LST

≥ 70 mm

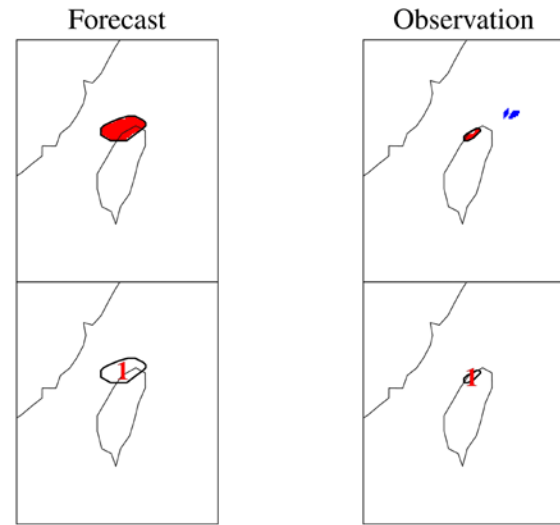
WRFD

WEPS PM

Cluster Object Information



Cluster Object Information



CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR	CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR
1	14.92	46.06	296	41	0	337	337	93.69	101.40	135.11	157.16	0.6185	1	4.94	17.02	382	41	41	382	341	92.72	101.40	149.10	157.16	0.8902

simulated better (total interest higher)

# Summary and future work

- Evaluation of high-impact weather is moving toward use of **spatial verification** methods.
- **MODE** have been applied to assess QPF performance of **CWB WRF and WEPS in a Meiyu frontal rainfall of June 2012.**
- Detailed study of the location errors and forecast bias over mountain/plain areas.
- Using MODE to define the **rainfall event** from different **weather systems**, e.g., winter fronts, typhoons, afternoon thunderstorms...

# Thank You