

# Verifying WRF with Objects

Running MODE and MODE  
analysis tool

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# Running MODE - Input

- Two fields, same grid, possibly different variables
  - forecast (fcst\_file) and observation (obs\_file)



- configuration settings (config\_file)
- syntax
  - `>mode fcst_file obs_file config_file`

# Running MODE - Output

- PostScript
  - object pictures
  - input parameter summary
  - total interest for each object pair

# MODE: APCP\_01 at SFC vs APCP\_01 at SFC

Forecast

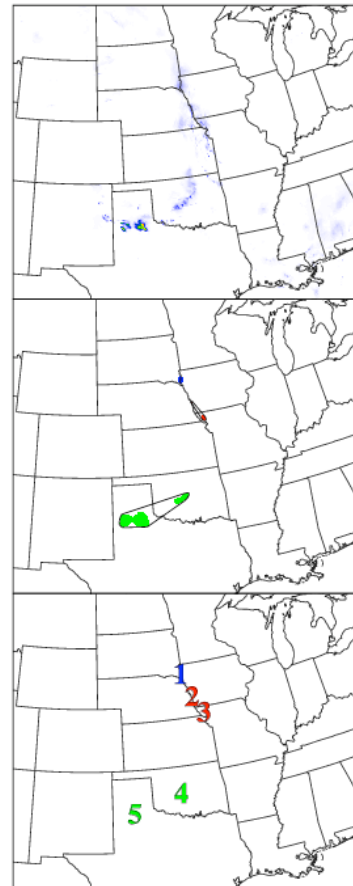
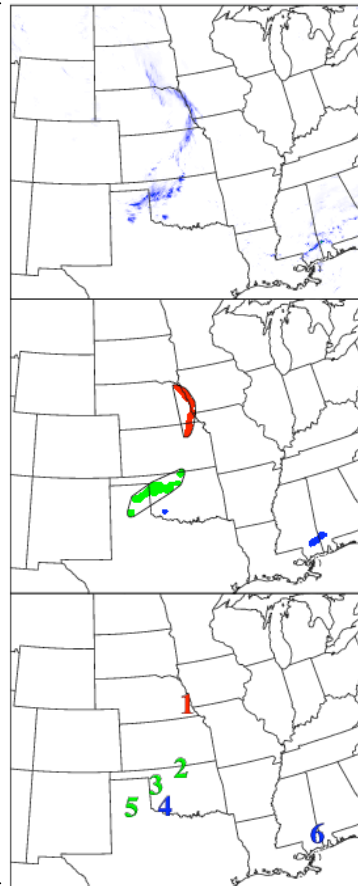
Observation

Fcst Obs Interest

1	2	0.7464
2	4	0.7350
3	5	0.7308

5	5	0.6874
4	4	0.6793
3	4	0.6582
1	3	0.6094
1	1	0.6075
5	4	0.5700
4	5	0.5696
2	3	0.4122
2	5	0.3854
1	4	0.3699
2	1	0.3437
2	2	0.2844
3	3	0.2816
4	3	0.2760
3	2	0.2260
3	1	0.1351
4	2	0.1027
6	1	N/A
4	1	N/A
5	2	N/A
6	4	N/A
1	5	N/A
5	3	N/A
6	3	N/A
6	2	N/A
5	1	N/A
6	5	N/A

object pictures



object-pairs  
total interest

model info  
name, times

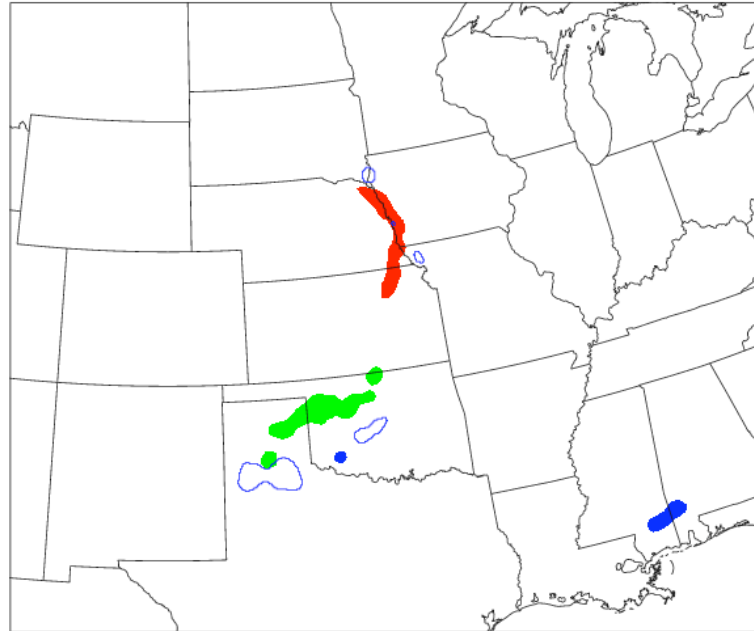
Model Name: wrf2caps  
Init Time: May 31, 2005 00:00:00  
Valid Time: Jun 1, 2005 00:00:00  
Lead Time: 24:00:00  
Accum Time: 01:00:00  
Centroid Distance: 4.00  
Boundary Distance: 6.00  
Convex Hull Distance: 0.00  
Angle Difference: 2.00  
Area Ratio: 3.00  
Intersection/Area: 2.00  
Complexity Ratio: 0.00  
Intensity Ratio: 0.00  
Total Interest Thresh: 0.70

object-attribute  
weights

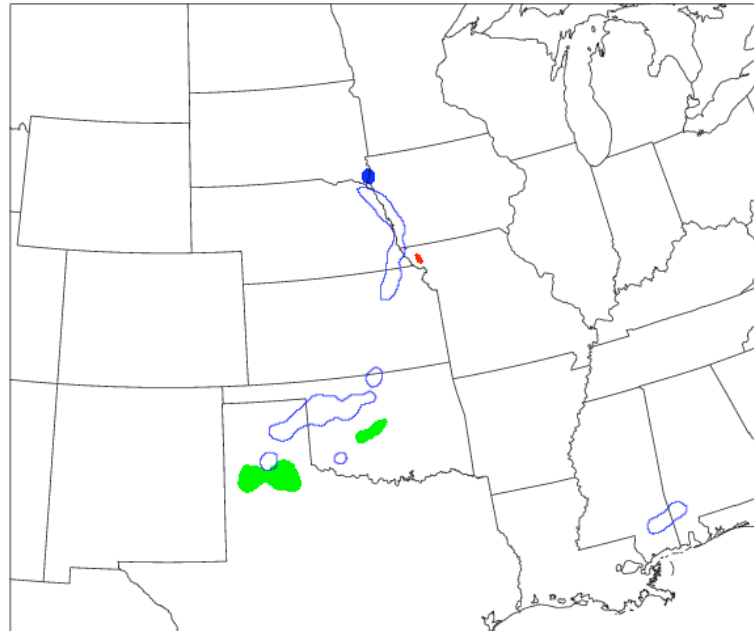
	Forecast	Observation
Mask Missing:	off	off
Mask Gr/Ply:	off/off	off/off
Raw Thresh:	$\geq 0.000 \text{ kg/m}^2$	$\geq 0.000 \text{ kg/m}^2$
Conv Radius:	7 gs	7 gs
Conv Thresh:	$\geq 7.000 \text{ kg/m}^2$	$\geq 7.000 \text{ kg/m}^2$
Area Thresh:	$\geq 0.000 \text{ gs}$	$\geq 0.000 \text{ gs}$
Inten Perc:	100 th	100 th
Inten Thresh:	$\geq 0.000 \text{ kg/m}^2$	$\geq 0.000 \text{ kg/m}^2$
Merge Thresh:	$\geq 1.750 \text{ kg/m}^2$	$\geq 1.750 \text{ kg/m}^2$
Merging:	thresh	thresh
Matching:	match/merge	
Simple(M/U):	6 (4/2)	5 (4/1)
Composites:	2	2

parameter  
summary  
threshold  
smoothing radius  
match/merging

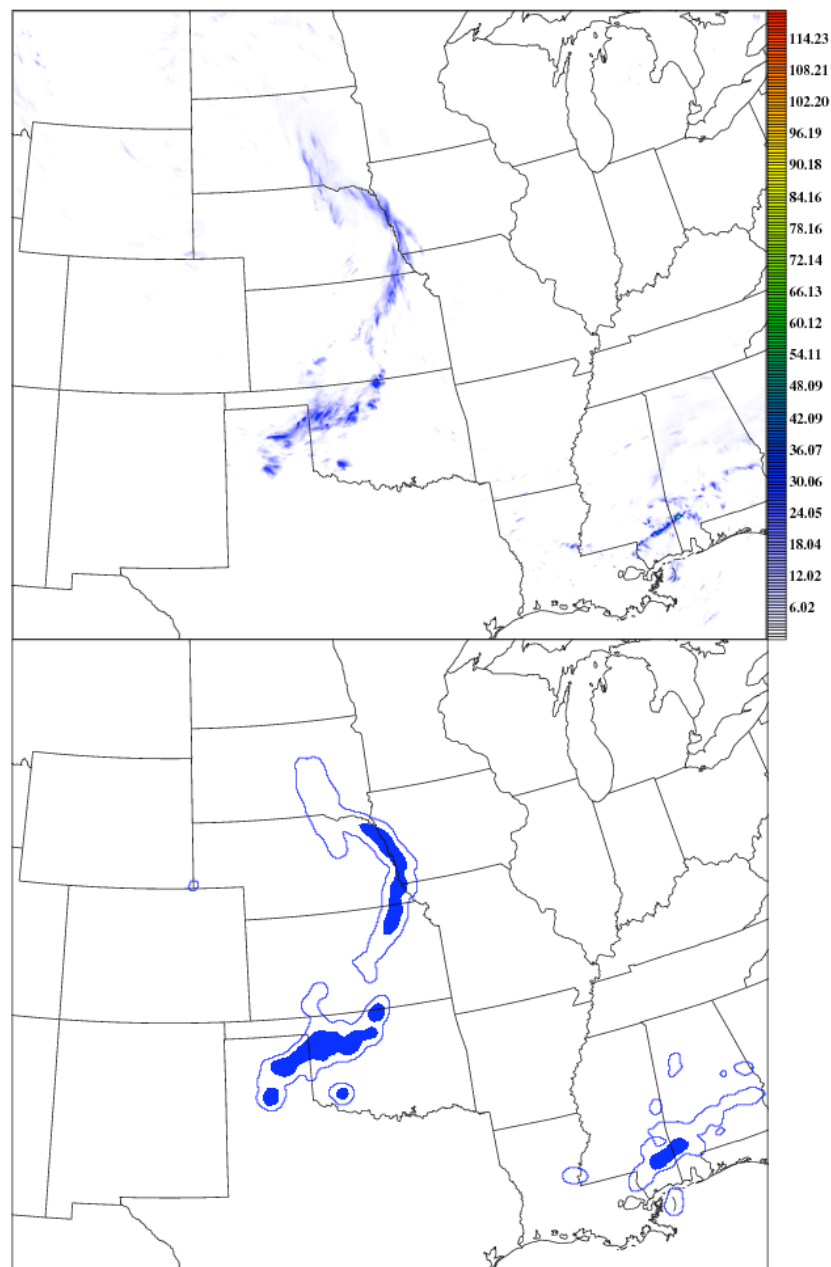
Forecast Objects with Observation Outlines



Observation Objects with Forecast Outlines



## Forecast: Threshold Merging



# Running MODE - Output

- PostScript
  - object pictures
  - input parameter summary
  - total interest for each object pair
- ASCII
  - object sizes, shapes, positions
  - stats for simple, paired objects and clusters
  - standard contingency table stats based on objects
- netCDF
  - gridded object fields

# Interpretation of MODE output

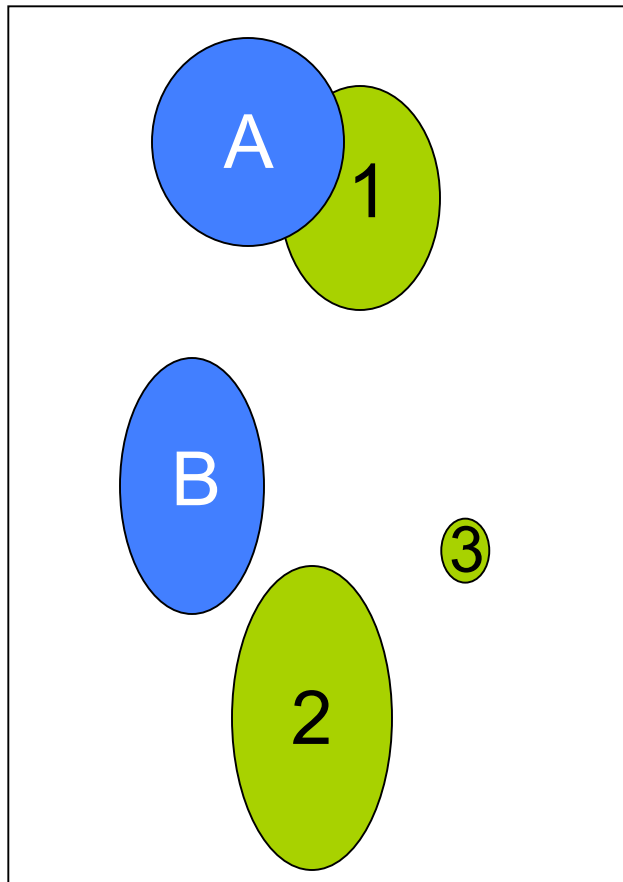
- Potential questions
  - How well do objects match?
    - median of the maximum interest (MMI)\*
  - What % of objects are matched?
  - What is the direction of displacement for matched objects
- mode\_analysis tool

\* Davis et al., 2009: The Method for Object-based Diagnostic Evaluation (MODE) Applied to WRF Forecasts from the 2005 SPC Spring Program. Submitted to Weather and Forecasting

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# Median of the Max. Interest (MMI)



Interest Matrix

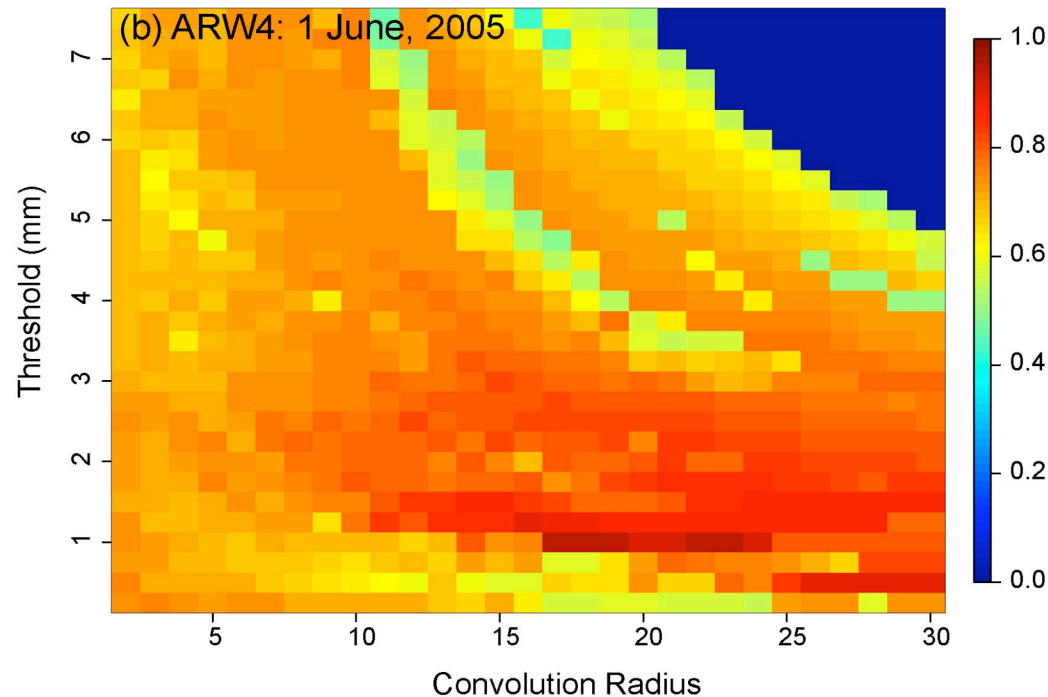
observed

		A	B
forecast	1	0.90	0.65
	2	0.50	0.80
	3	0.40	0.55

$$\text{MMI} = \text{median} \{ 0.90, 0.80, 0.55, 0.90, 0.80 \} = 0.80$$

# Median of the Max. Interest (MMI)

## “Quilt” Plot



MMI as a function of object smoothing radius and rainfall threshold  
(related to spatial scale)

Quilt plot is good for determining the best spatial scale to obtain  
inferences about matched objects.

# What % of Objects are Matched?

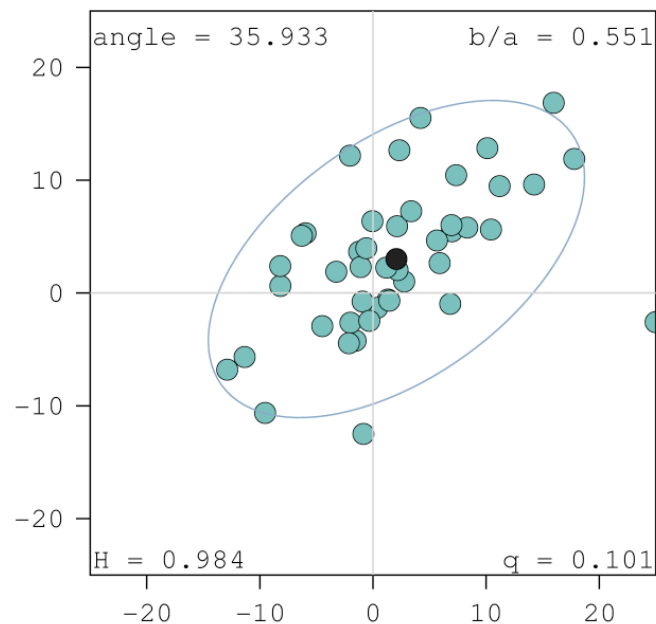
- Hit rate, Threat Score, Heidke Skill Score
- Other standard contingency table scores

	Observed object	Unobserved object
Forecasted object	Matched	False alarm
Unforecasted object	Missed	Correct null

# MODE Analysis

- displacement of forecast clusters from matched observed clusters

*Composite Object Centroid Differences  
over the Appalachian Mountains*



# MODE Analysis Tool

## SUMMARY Example

### *Command Line*

```
mode_analysis -summary
               -mask_file ttt -config config/mode_test_config \
               -dump_lines out -lookin /dl/score/mode_files \
               -fcst -composite -area_min 3000 \
               -centroid_x_min 600
               -centroid_x_max 1100 \
               -column CENTroid_x \
               -column centroid_y \
               -column centroid_lat \
               -column centroid_lon \
               -column area \
               -column axis_ang \
               -column length
```

### *Output*

```
Total mode lines read = 73,330
Total mode lines kept = 539
```

Field	Min	Max	Mean	StdDev	P10	P25	P50	P75	P90
centroid_x	600.23	914.61	779.36	97.98	626.36	687.96	804.30	866.75	894.24
centroid_y	55.22	560.08	335.55	113.08	189.48	240.58	333.51	421.06	496.82
centroid_lat	22.00	40.14	32.08	4.06	26.83	28.66	32.00	35.15	37.87
centroid_lon	-107.03	-95.01	-100.18	3.75	-106.03	-103.67	-99.23	-96.84	-95.79
area	3210.00	85486.00	12680.96	9931.67	4935.00	6256.00	9445.00	16106.00	23678.00
axis_ang	-88.84	89.90	13.54	44.82	-55.80	-16.36	17.28	48.23	71.27
length	100.57	494.54	200.08	82.11	112.44	133.62	179.96	249.06	315.33

# MODE Analysis Tool

## By Case Example

### Command Line

```
mode_analysis -bycase
              -dump_lines out
              -mask_file ttt -config config/mode_test_config
              -fcst_valid_min 20070702 -fcst_valid_max 20070702_12
              -area_min 3000
              -centroid_x_min 600 -centroid_x_max 1100
              /dl/score/mode_files/ncwf2_vs_ncwdp/* /dl/score/mode_files/rcpf_vs_ncwdp/*
```

### Output

Fcst Valid Time	Area Matched	Area Unmatched	# Fcst Matched	# Fcst Unmatched	# Obs Matched	# Obs Unmatched
Jul 2, 2007 00:00:00	12392	20786	0	1	1	1
Jul 2, 2007 01:00:00	6706	11038	0	0	1	2
Jul 2, 2007 02:00:00	7507	18696	0	0	1	3
Jul 2, 2007 03:00:00	19401	32268	2	3	1	2
Jul 2, 2007 04:00:00	0	16551	0	2	0	1
Jul 2, 2007 05:00:00	15311	29730	1	2	1	2
Jul 2, 2007 06:00:00	4730	8182	0	0	1	2
Jul 2, 2007 07:00:00	3733	13285	0	1	1	2
Jul 2, 2007 08:00:00	6994	6994	0	0	1	1
Jul 2, 2007 09:00:00	15981	15981	0	0	2	2
Jul 2, 2007 10:00:00	51501	53427	2	2	4	4
Jul 2, 2007 11:00:00	15779	21089	1	1	1	2
Jul 2, 2007 12:00:00	31339	40665	1	2	2	2

# Thurs AM Lecture Wrap-Up

- Confidence intervals
- Verifying WRF with objects
  - Matching
  - merging
- Running MODE
  - MODE analysis
- Questions?

