

Running MODE and MODE Analysis Tool



Verifying WRF with Objects

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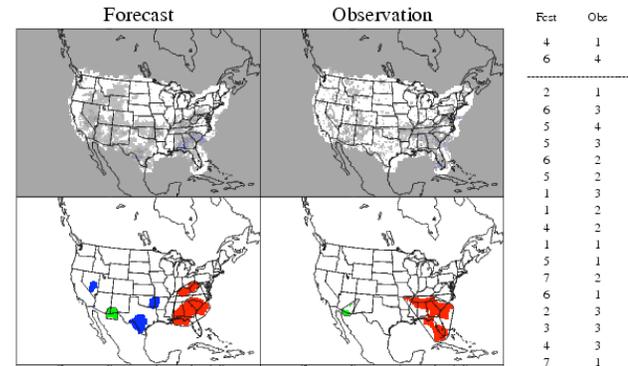
Running MODE - Input



- 2 fields on the same grid
 - **F** (forecast_file) and **O** (observation_file)
- configuration settings (config_file)
- Usage
 - > `mode forecast_file observation_file config_file`

Running MODE - Output

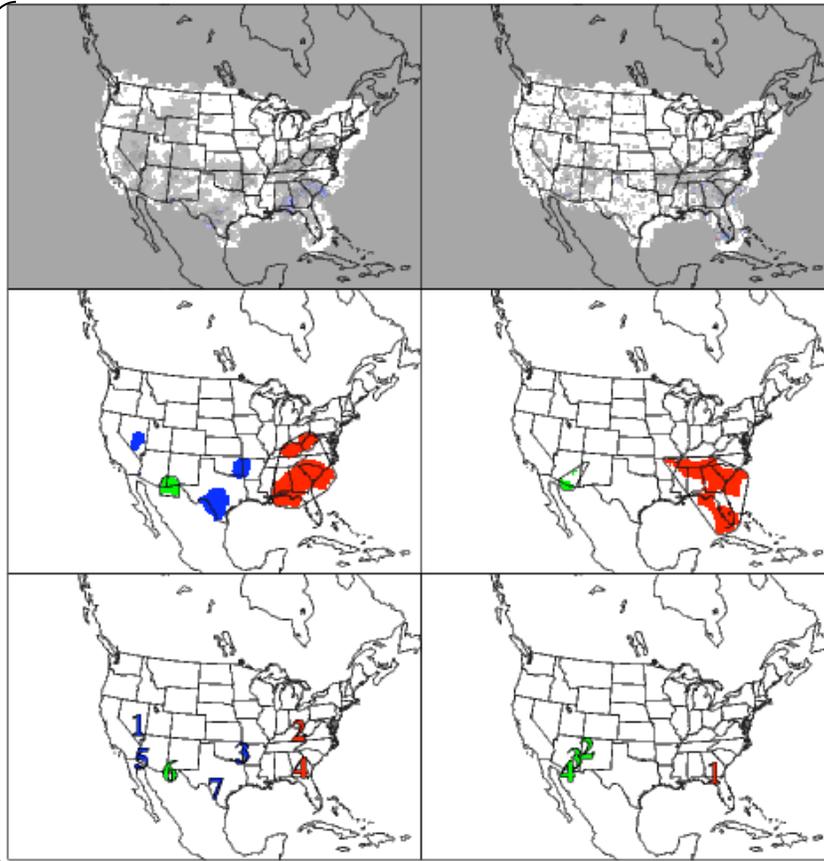
- PostScript
 - object pictures
 - parameter summary
 - total interest for each object pair



MODE: APCP_12 at SFC vs APCP_12 at SFC

Forecast

Observation



object pictures

| Fcst | Obs | Interest |
|-------|-----|----------|
| 4 | 1 | 0.9175 |
| 6 | 4 | 0.8301 |
| <hr/> | | |
| 2 | 1 | 0.5589 |
| 6 | 3 | 0.5027 |
| 5 | 4 | 0.4328 |
| 5 | 3 | 0.2430 |
| 6 | 2 | 0.2384 |
| 5 | 2 | 0.1111 |
| 1 | 3 | 0.0898 |
| 1 | 2 | 0.0123 |
| 4 | 2 | NA |
| 1 | 1 | NA |
| 5 | 1 | NA |
| 7 | 2 | NA |
| 6 | 1 | NA |
| 2 | 3 | NA |
| 3 | 3 | NA |
| 4 | 3 | NA |
| 7 | 1 | NA |
| 3 | 1 | NA |
| 7 | 3 | NA |
| 1 | 4 | NA |
| 2 | 4 | NA |
| 3 | 4 | NA |
| 4 | 4 | NA |
| 2 | 2 | NA |
| 3 | 2 | NA |
| 7 | 4 | NA |

object-pairs
total interest

model info

name, times

| | Forecast | Observation | Forecast | Observation |
|-------------------------|----------|-------------|---------------|-------------|
| Model: | WRF | | Mask M/G/P: | on/off/off |
| Field: | APCP_12 | APCP_12 | Raw Thresh: | >=0.00 |
| Level: | SFC | SFC | Conv Radius: | 5 gs |
| Units: | kg/m^2 | kg/m^2 | Conv Thresh: | >=2.50 |
| Initial: | 20050807 | 20050807 | Area Thresh: | >=0 gs |
| | 00:00:00 | 12:00:00 | Inten Thresh: | p100>=0.00 |
| Valid: | 20050807 | 20050807 | Merge Thresh: | >=1.25 |
| | 12:00:00 | 12:00:00 | Merging: | thresh |
| Accum: | 12:00:00 | 12:00:00 | Matching: | match/merge |
| | | | Simple/M/U: | 7/3/4 |
| Centroid/Boundary: | 2.00 | 4.00 | Area: | 944 gs |
| Convex Hull/Angle: | 0.00 | 1.00 | Area M/U: | 628/316 |
| Area/Intersection Area: | 1.00 | 2.00 | Cluster: | 2 |
| Complexity/Intensity: | 0.00 | 0.00 | MMI: | 0.4328 |
| Total Interest Thresh: | | 0.70 | MMI (F+O): | 0.5027 |

object-attribute
weights

parameter

summary

threshold

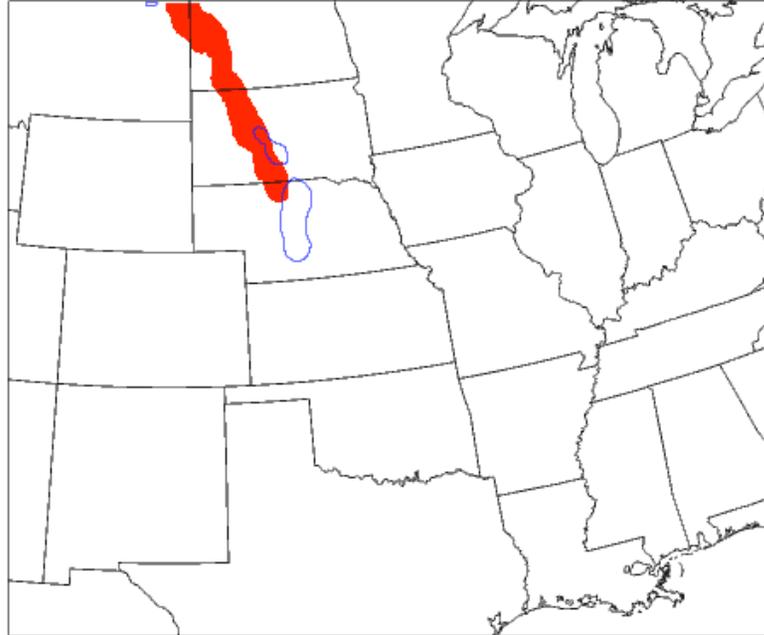
smoothing radius

match/merge

stats

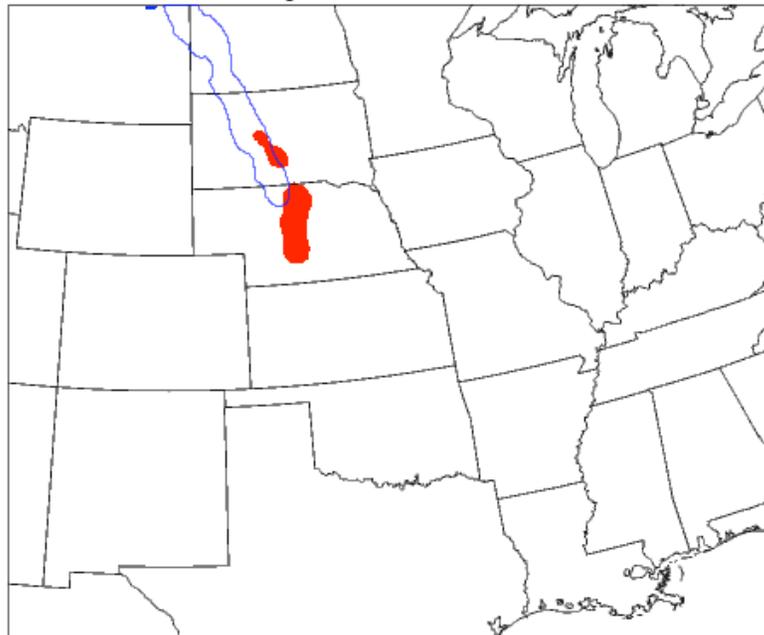
MMI

Forecast Objects with Observation Outlines



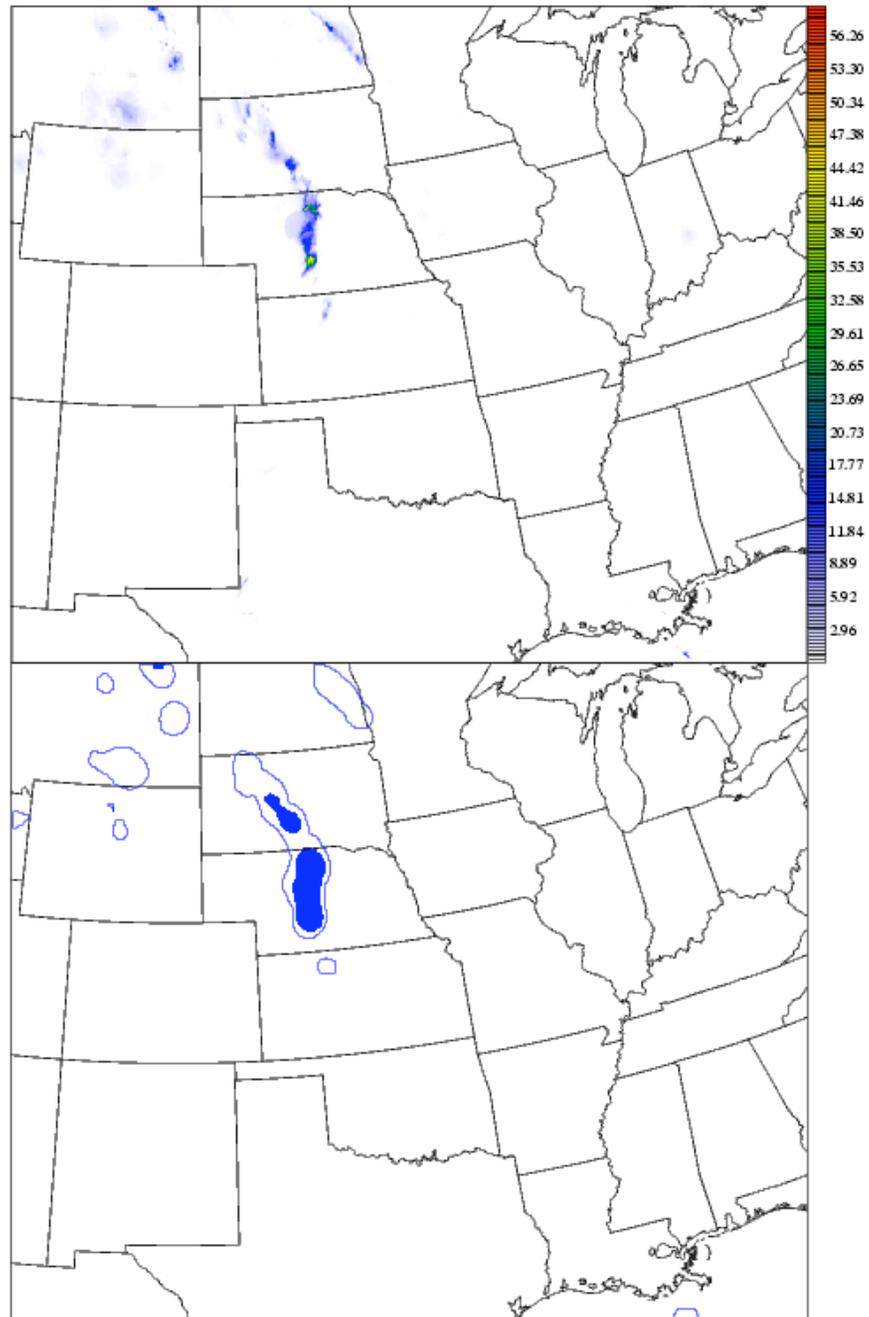
Forecast and Observation
Overlaid

Observation Objects with Forecast Outlines



Merging Objects with Double Threshold

Observation: Threshold Merging

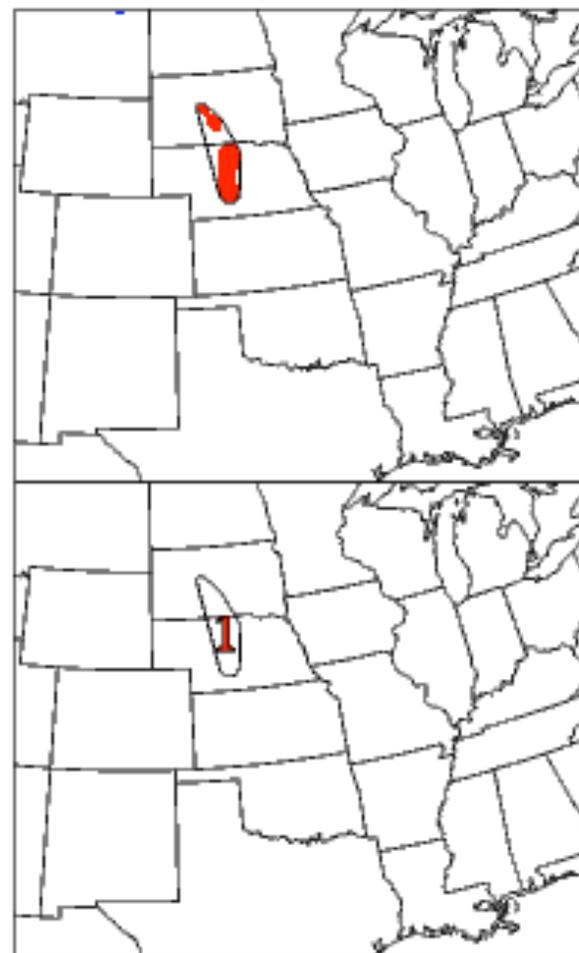


Cluster Object Information

Forecast



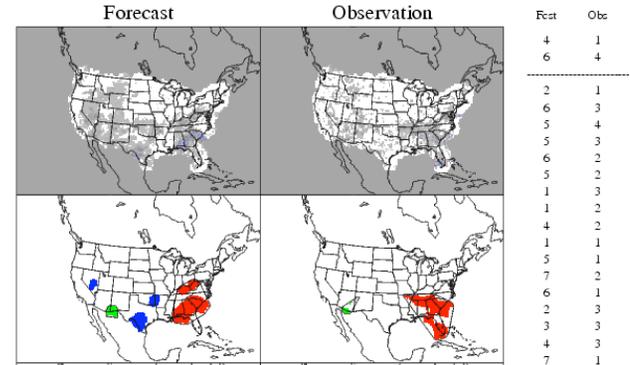
Observation



| CLUS PAIR | CEN DIST | ANG DIFF | FCST AREA | OBS AREA | INTER AREA | UNION AREA | SYM DIFF | FCST INT50 | OBS INT50 | FCST INT90 | OBS INT90 | TOT INTR |
|-----------|----------|----------|-----------|----------|------------|------------|----------|------------|-----------|------------|-----------|----------|
| 1 | 97.32 | 12.16 | 4184 | 1762 | 358 | 5588 | 5230 | 5.33 | 4.06 | 16.51 | 15.57 | 0.7622 |

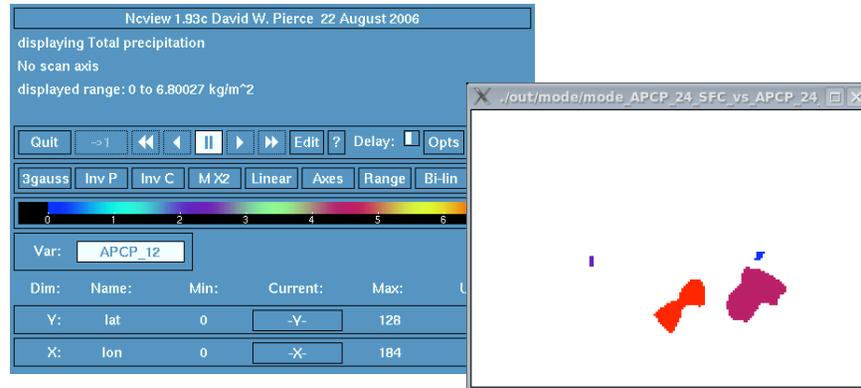
Running MODE - Output

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



- ASCII
 - object sizes, shapes, positions
 - stats for simple, paired objects and clusters
 - standard contingency table stats on smoothed and thresholded fields (objects)

- netCDF
 - gridded object fields
 - view with ncview



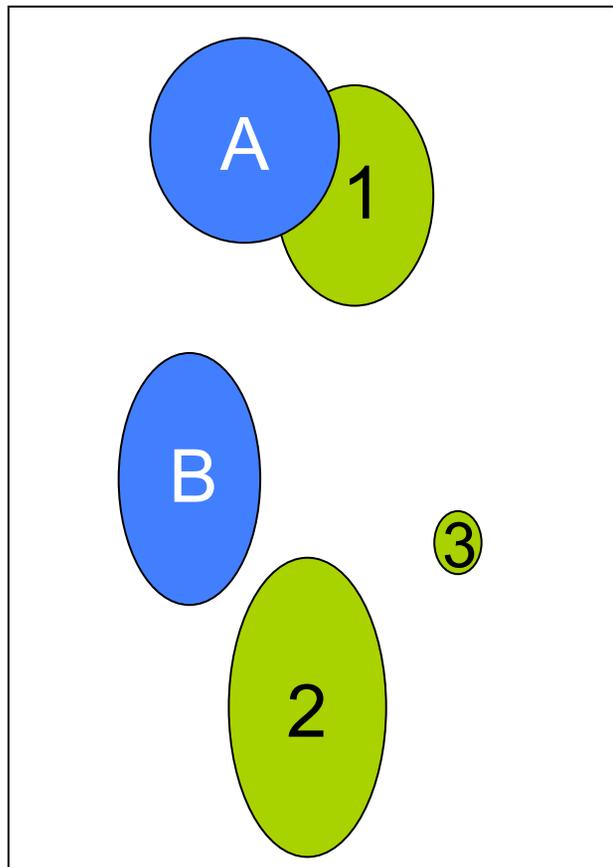
Interpreting MODE Output

- Sample Questions
 1. How well do objects match?
 - median of the maximum interest (MMI)*
 2. What fraction of objects are matched?
 - hit rate, threat score
 3. Displacement of matched objects
- Tool to answer questions
 - mode_analysis

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

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Median of the Max. Interest (MMI)



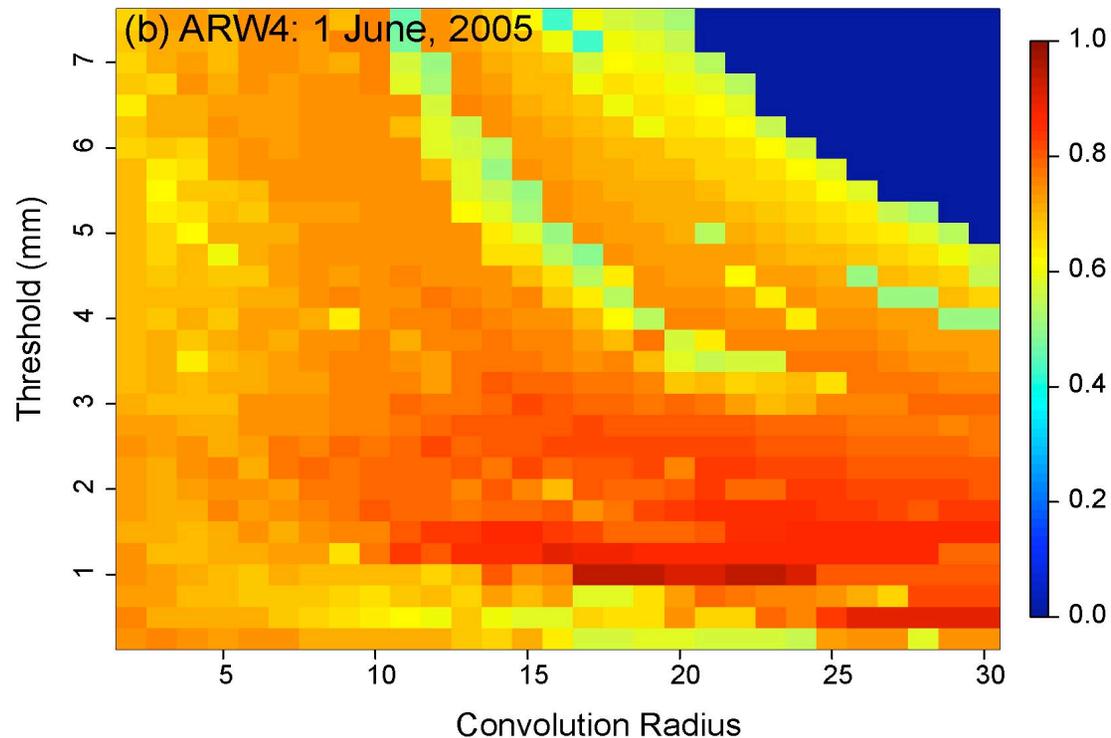
Interest Matrix

observed

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

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

Median of the Max. Interest (MMI) Quilt Plot



MMI as a function of convolution radius (grid squares) and threshold (mm) for 24-h forecast of 1-h rainfall

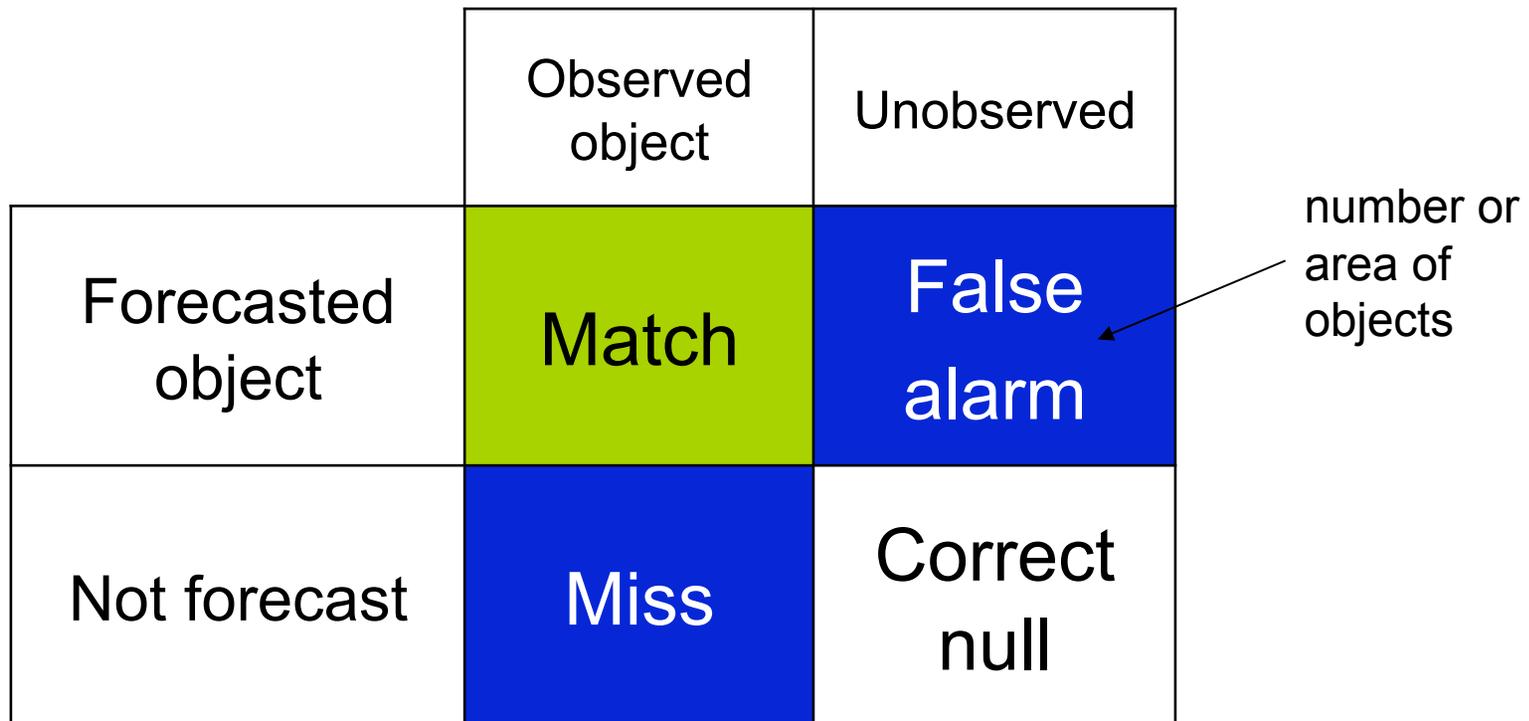
- This graphic is not in MET.
- Each pixel is a MODE run.
- R code on website.

What Fraction of Objects are Matched?

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

| | Observed object | Unobserved |
|-------------------|-----------------|--------------|
| Forecasted object | Match | False alarm |
| Not forecast | Miss | Correct null |

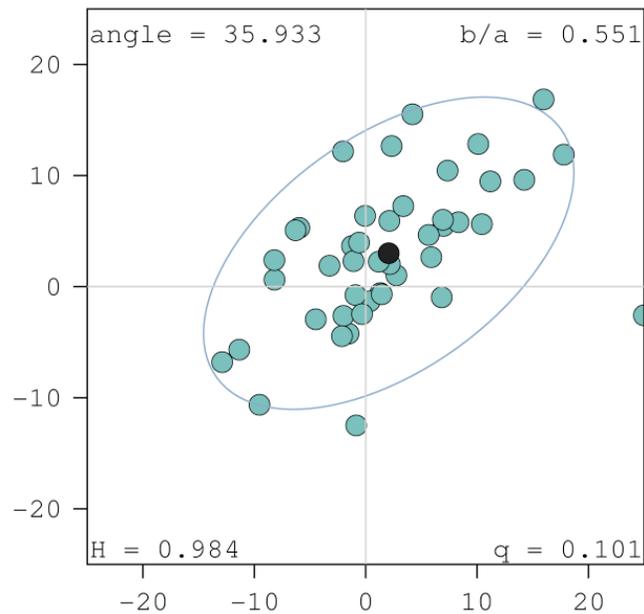
number or area of objects



MODE Analysis

- Displacement error of forecast clusters

*Composite Object Centroid Differences
over the Appalachian Mountains*



MODE Analysis Tool

Summary Example

Command Line

```
mode_analysis -summary \  
  -lookin mode_output/wrf4ncep/40km/ge03.\  
  -fcst -cluster \  
  -area_min 100 \  
  -column centroid_lat -column centroid_lon \  
  -column area \  
  -column axis_ang \  
  -column length
```

Output

```
Total mode lines read = 393  
Total mode lines kept = 17
```

| Field | N | Min | Max | Mean | StdDev | P10 | P25 | P50 | P75 | P90 | Sum |
|--------------|----|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| centroid_lat | 17 | 31.97 | 46.24 | 38.65 | 3.81 | 33.89 | 36.13 | 38.54 | 40.12 | 43.99 | 657.00 |
| centroid_lon | 17 | -103.89 | -85.20 | -96.32 | 5.91 | -103.15 | -102.65 | -96.26 | -93.95 | -86.78 | -1637.49 |
| area | 17 | 180.00 | 8393.00 | 2955.06 | 2246.49 | 624.80 | 1206.00 | 2662.00 | 3958.00 | 5732.20 | 50236.00 |
| axis_ang | 17 | -88.63 | 85.66 | 12.62 | 64.35 | -70.77 | -63.86 | 35.04 | 74.37 | 79.24 | 214.60 |
| length | 17 | 25.25 | 234.76 | 124.41 | 60.99 | 48.85 | 65.37 | 116.67 | 169.37 | 204.57 | 2114.90 |

MODE Analysis Tool

By-case Example

Command Line

```
mode_analysis -bycase -lookin mode_output/wrf4ncep/40km/ge03. \  
-single -cluster \  
-area_min 100
```

Output

```
Total mode lines read = 393  
Total mode lines kept = 17
```

| Fcst Valid Time | Area Matched | Area Unmatched | # Fcst Matched | # Fcst Unmatched | # Obs Matched | # Obs Unmatched |
|-----------------------|--------------|----------------|----------------|------------------|---------------|-----------------|
| Apr 26, 2005 00:00:00 | 2685 | 0 | 1 | 0 | 1 | 0 |
| May 13, 2005 00:00:00 | 3958 | 0 | 1 | 0 | 1 | 0 |
| May 14, 2005 00:00:00 | 11695 | 0 | 2 | 0 | 2 | 0 |
| May 18, 2005 00:00:00 | 4295 | 0 | 1 | 0 | 1 | 0 |
| May 19, 2005 00:00:00 | 1206 | 0 | 1 | 0 | 1 | 0 |
| May 25, 2005 00:00:00 | 4457 | 0 | 2 | 0 | 2 | 0 |
| Jun 1, 2005 00:00:00 | 8256 | 0 | 3 | 0 | 3 | 0 |
| Jun 3, 2005 00:00:00 | 5319 | 0 | 3 | 0 | 3 | 0 |
| Jun 4, 2005 00:00:00 | 8365 | 0 | 3 | 0 | 3 | 0 |

Interpreting MODE

- MODE Input and Output
- Sample Verification Questions
- Mode Analysis Tool

