MODE (Method for Object-based Diagnostic Evaluation)

- NCAR

**MODE Input**

- Gridded text files with lat-lon info
- GRIB
- Precipitation rate or accumulation
- Reflectivity
- Any field that can be thought of as “objects”
MODE Object Identification

2 parameters:
1. Convolution radius
2. Threshold
Identifying and Merging Objects

1 June, 2005  1-hour precip

Solid blue blobs:
Convolution radius 15 grid pts
Precip threshold 0.05"

Thin outline
Precip threshold 0.0125"
Fuzzy logic mergers

Centroid distance
Fuzzy logic mergers

Minimum boundary distance
Fuzzy logic mergers

orientation
Matching Observed & Forecasted Objects

StageII

WRF

False alarms
Fuzzy logic matches

Overlap
Size ratio
Median intensity ratio
Complexity ratio
MODE output

- Attributes of composite observed and forecast objects and their relationships
  - EX: Area, Intensity, Volume, Location, Shape, + differences and ratios
- Attributes of single matched shapes (i.e., “Hits”)
- Attributes of single unmatched shapes (i.e., “False Alarms”, “Misses”)
- Attributes of interest to specific users (e.g., gaps between storms, for aviation strategic planning)
- Attributes can be summarized across many cases to
  - Understand how forecasts represent the storm/precip climatology
  - Understand systematic errors
  - Document variability in performance in different situations
  - Etc.
**MODE Strengths and Weaknesses**

- **Strengths**
  - Allows and quantifies spatial offsets
  - Gives credit to a “good enough” forecast
  - Tuned to particular object intensity and size

- **Weaknesses**
  - Many tunable parameters
Convolution radius / Intensity threshold

fraction of single objects matched

00 UTC, 1 June 2005
**MODE Object-based approach**

- **Identification**
- **Measure Attributes**
- **Merging**
- **Matching**
- **Comparison**
- **Summarize**

**Convolution – threshold process**

**Fuzzy Logic Approach**
- Merge simple objects into composite objects
- Compute interest values
- Identify matched pairs
- Accumulate and examine comparisons across many cases
**Gridded forecast example: Summary**

**Locations:**
Forecast objects are
- Too far North (except B)
- Too far West (except C)

**Precipitation intensity:**
- Median intensity is too large
- Extreme (0.90<sup>th</sup>) intensity is too small

**Size:**
- Forecasts C and D are too small
- Forecast B is somewhat too large

**Matching:**
- Two small observed objects were not matched

POD = 0.27
FAR = 0.75
CSI = 0.34
Example: Summary across many forecasts

Does precipitation intensity vary between Forecast and Observed objects?

**Median**

<table>
<thead>
<tr>
<th>Region</th>
<th>East</th>
<th>West</th>
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**0.90th Quantile**

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S = Stage 4 precip (Observed); W = WRF Forecast
Application examples: Distribution of spatial errors

Distribution of Spatial Errors
Matching and Forecast “Skill”

Much greater dependence of forecast error on the size of objects than on forecast lead time

\[
\text{CSI} = \frac{YY}{YY + NY + YN}
\]
Quilt plots for different models
June 1, 2005

ARW 4-km

Displacement 24.6 km

Displacement 30 km

NMM 4-km

Displacement 14.6 km

Displacement 19 km
Region with large radius and large threshold has low rate of matches, except for most extreme values.

Region with moderate values of radius and low threshold (around 5) is the scale with best potential for object matching.
7-30h forecast animations

- May 13, 2005
- June 1, 2005
24-h fcst valid 1Jun 2005, 00 UTC
R=15 T=.05”
R=10 T=.10”
hit
false alm
miss
3 Fake forecasts

- Real observations
  - Shifted 50 grid points (~200 km) southeast
  - Same shift and scaled 2x
  - Same shift with 0.05” subtracted
1 June 2005

9 Cases