Defining Objects in MODE
What are Objects?

Raw Field

Object Field

Objects are Regions of Interest
Step #1

Start with the raw data field.

In this case, a precipitation field.
Step #2

Apply convolution operator.

This is basically a smoothing operation.
Convolution Radius

Radius of Influence
Convolution

Uses raw field $f(x, y)$ and filter function $\phi(x, y)$

$$C(x, y) = \sum_{(\hat{x}, \hat{y}) \in G} \phi(\hat{x}, \hat{y}) f(x - \hat{x}, y - \hat{y})$$
Step #3

Threshold the smoothed field.

This produces an on/off mask field.
Masking

Uses convolved field $C(x, y)$

and threshold $T$

$$M(x, y) = \begin{cases} 1 & \text{if } C(x, y) \geq T \\ 0 & \text{else} \end{cases}$$
Step #4

Restore original data to object interiors.

This gives us our objects.
Changing Object-Definition Parameters

Raw Field

R = 2
T = 2.29

R = 5
T = 0.76

R = 10
T = 0.76
Matching & Merging

Merging: Associating objects in the same field.

Matching: Associating objects in different fields.

MODE does this using a Fuzzy-Logic engine.
Example of Matching & Merging

Fcst Raw

Obs Raw

Fcst Obj

Obs Obj
<table>
<thead>
<tr>
<th>Single:</th>
<th>Pair:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Centroid Distance</td>
</tr>
<tr>
<td>Centroid</td>
<td>Angle Difference</td>
</tr>
<tr>
<td>Axis Angle</td>
<td>Median Intensity Ratio</td>
</tr>
<tr>
<td>Median Intensity</td>
<td>Intersection Area</td>
</tr>
<tr>
<td>Complexity</td>
<td>Convex Hull Distance</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>Boundary Distance</td>
</tr>
<tr>
<td>Curvature</td>
<td>Area Ratio</td>
</tr>
</tbody>
</table>
Example Single Attributes

- Centroid
- Axis
- Convex Hull
Example Pair Attributes

Forecast Object

Observed Object

Union

Intersection

Symmetric Difference

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Interest Maps

Map attributes to interest values.

Example: Centroid Distance

All interest maps can be changed in the config file.
Weights

Express relative importance of different attributes in matching and merging.

All weights can be changed in the config file.
Total Interest
Calculated from weights, attributes, and interest maps.

\[ T(\alpha) = \frac{\sum_{i} w_i C_i(\alpha) I_i(\alpha_i)}{\sum_{i} w_i C_i(\alpha)} \]
Alternative Merging Method

Double Thresholding