The Method for Object-based Diagnostic Evaluation (MODE)

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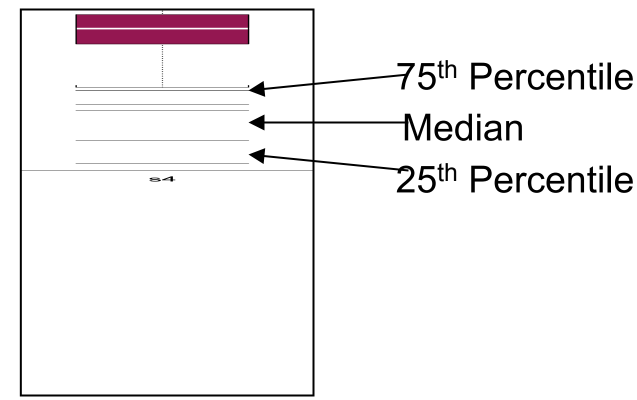
Relevant reference:

Davis, C. A., B. G. Brown, R. Bullock, and J. Halley-Gotway, 2009: The method for object-based diagnostic evaluation (MODE) applied to WRF forecasts from the 2005 NSSL/SPC spring program. Wea. Forecasting, Accepted.

NCAR

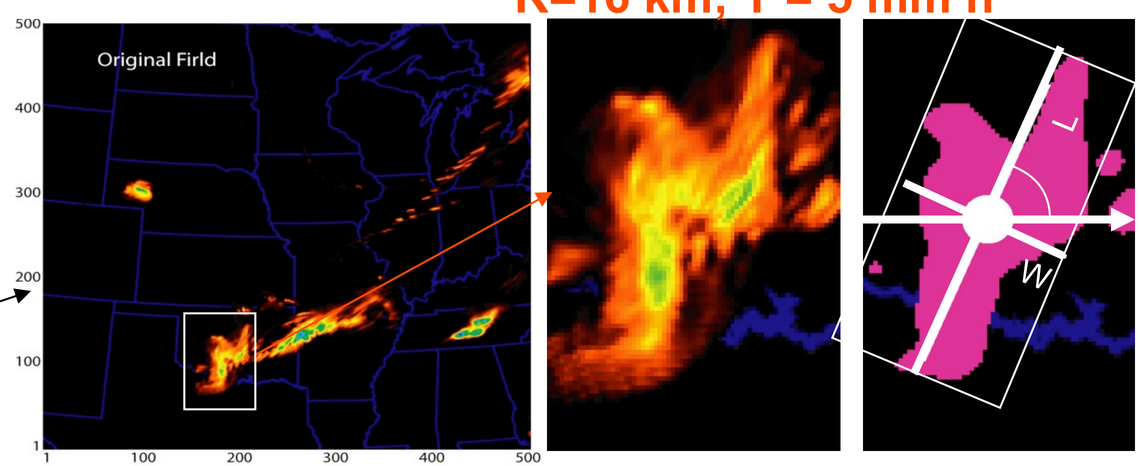
Object Identification and Attributes

- **Intensity** (percentile value)
- **Area** (# grid points > T)
- **Centroid**
- **Axis angle** (rel. to E-W)
- **Aspect ratio** (W/L)
- **Fractional Area**
- **Curvature**



R=16 km; T = 5 mm h^{-1}

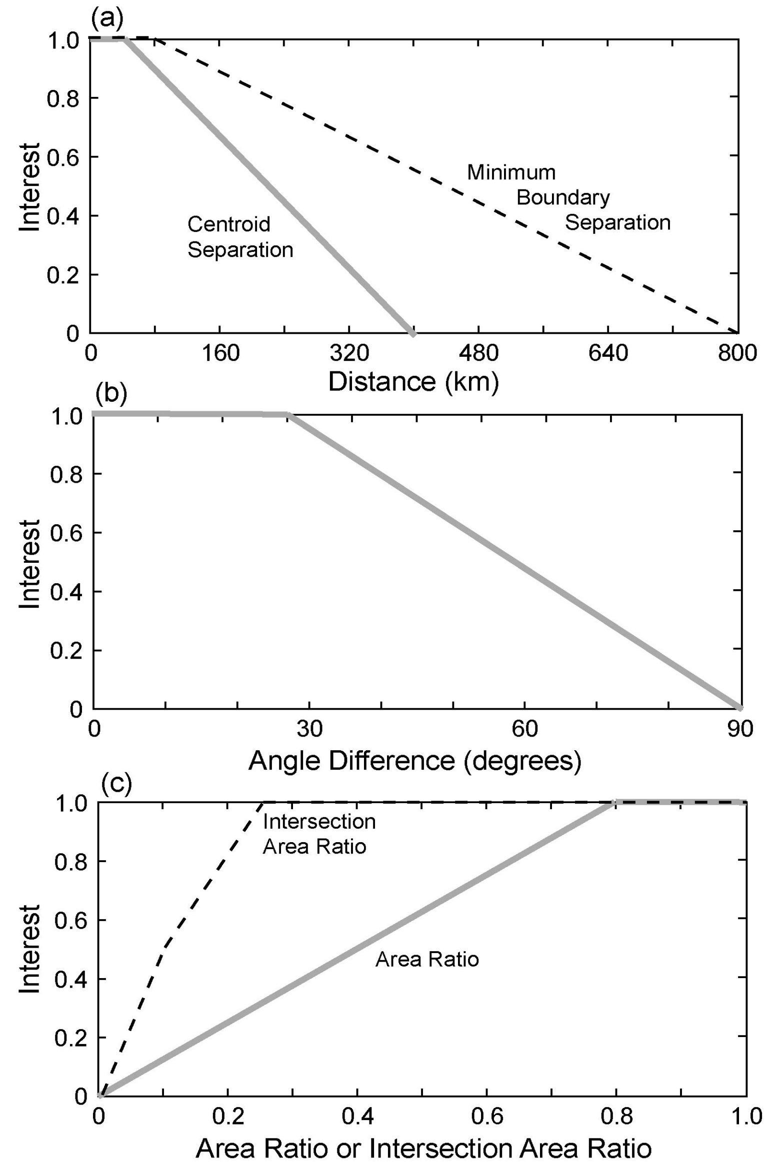
Raw Forecast (28 h, 04 UTC 11 June)



Interest Functions

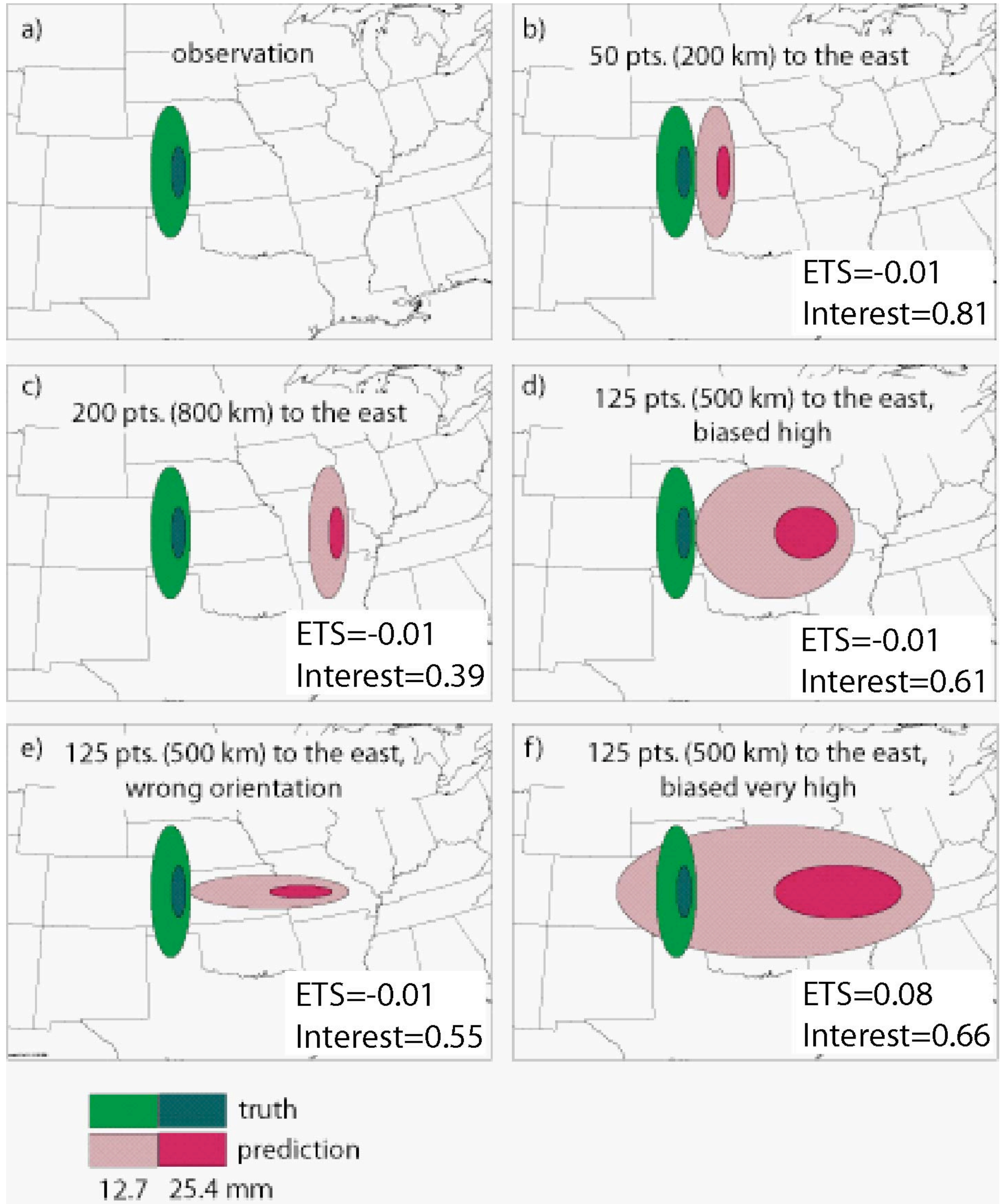
$$I_j = \frac{\sum_{i=1}^{M} c_i w_i F_{i,j}}{\sum_{i=1}^{M} c_i w_i}$$

For the j[th] pair of objects (forecast and observed)

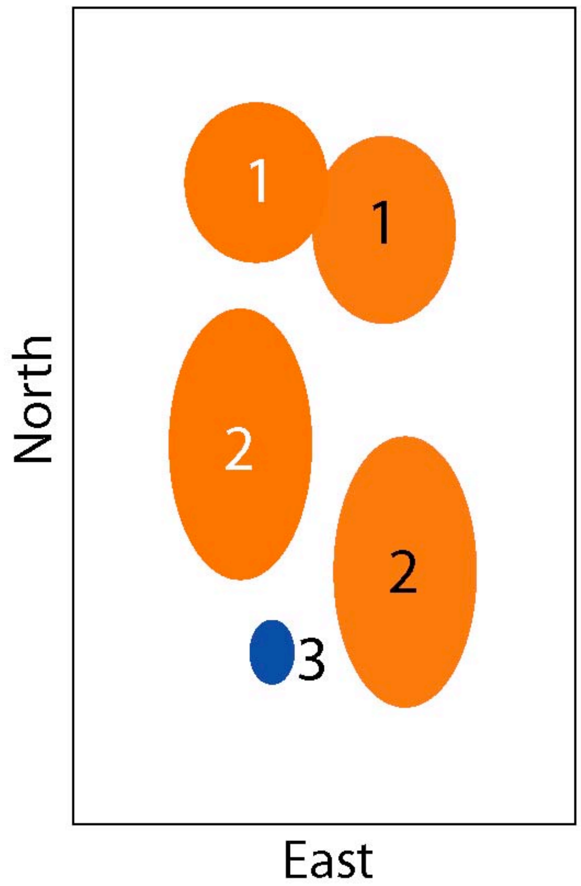


Geometric Cases

- Case ‘b’ highest
- Case ‘d’ higher than ‘c’
- Case ‘d’ higher than ‘e’
- Case ‘f’ not too bad



Interest Matrix



Interest Matrix

Observed

Forecast	1	2
1	0.90	0.75
2	0.50	0.80
3	0.40	0.55

Dependence on Object Definition

- For each object, indentify maximum interest value

- Compute median of all maximum interest values
    - Median of Maximum Interest for Forecast (**MMIF**)
    - Median of Maximum Interest for Obs (**MMIO**)
    - **MMI** = median of combined distributions of maximum interest

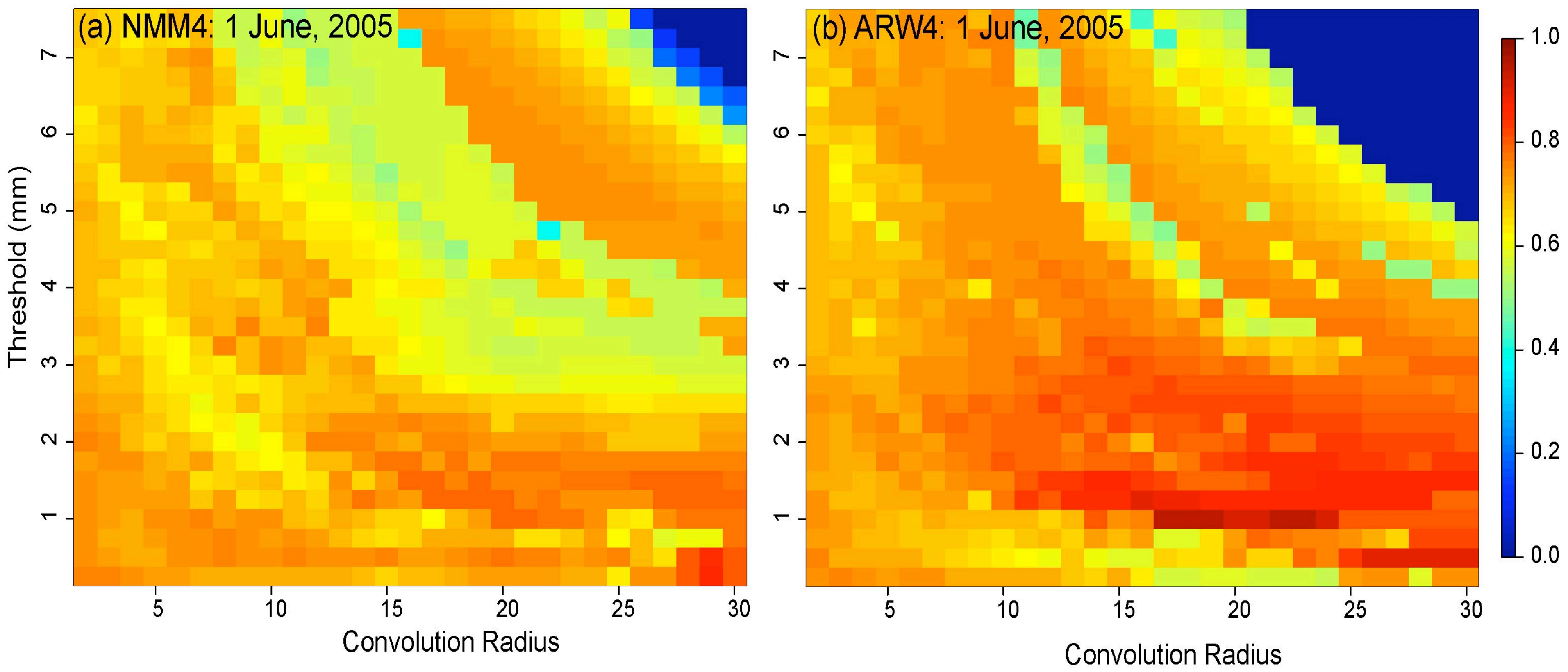
- Display as function of convolution radius and threshold

		Observed	
		1	2
Forecast	1	0.90	0.75
	2	0.50	0.80
	3	0.40	0.55

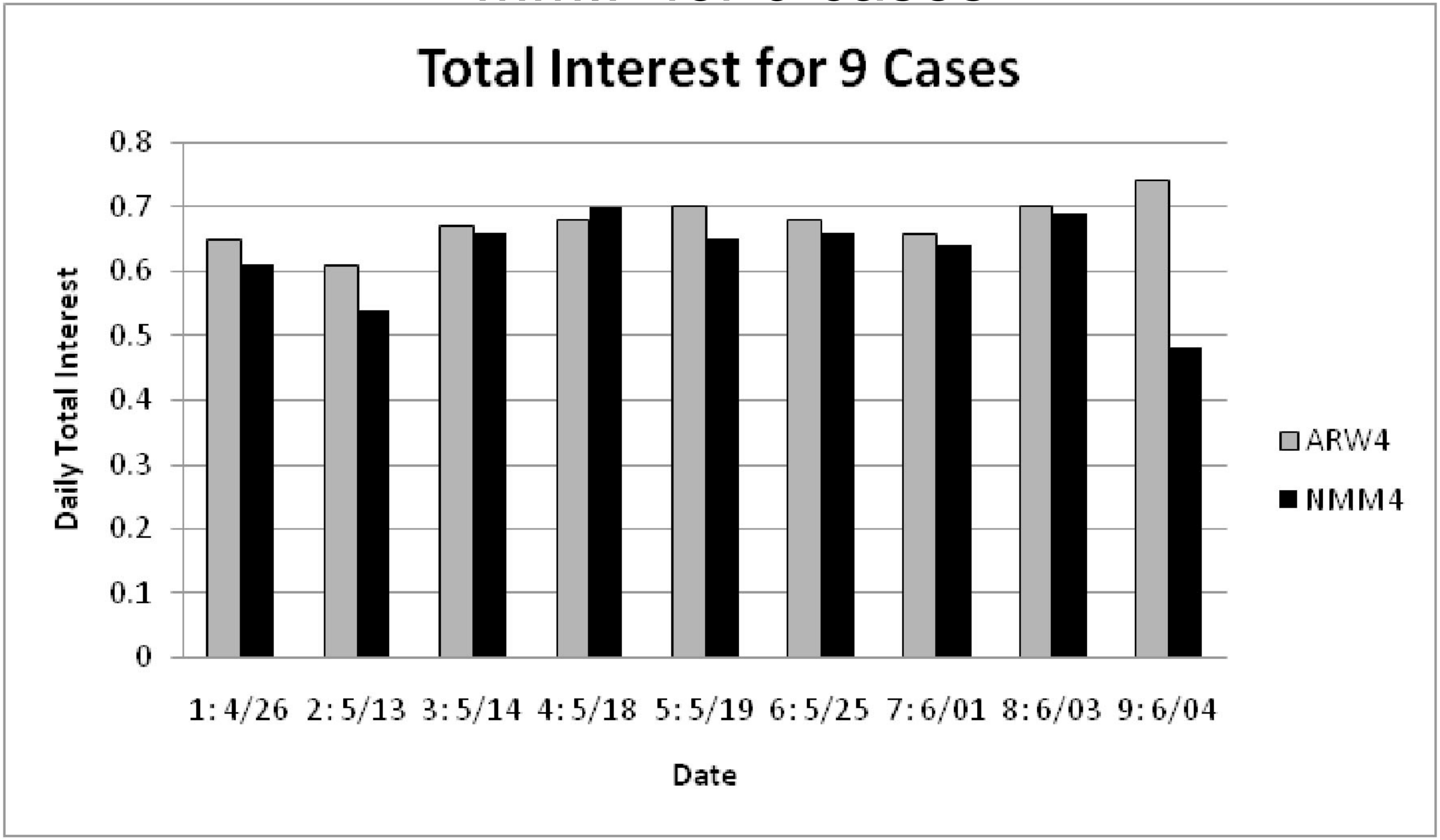
MMIF=0.80
MMIO=0.85
MMI=0.8

Dependence on Object Definition

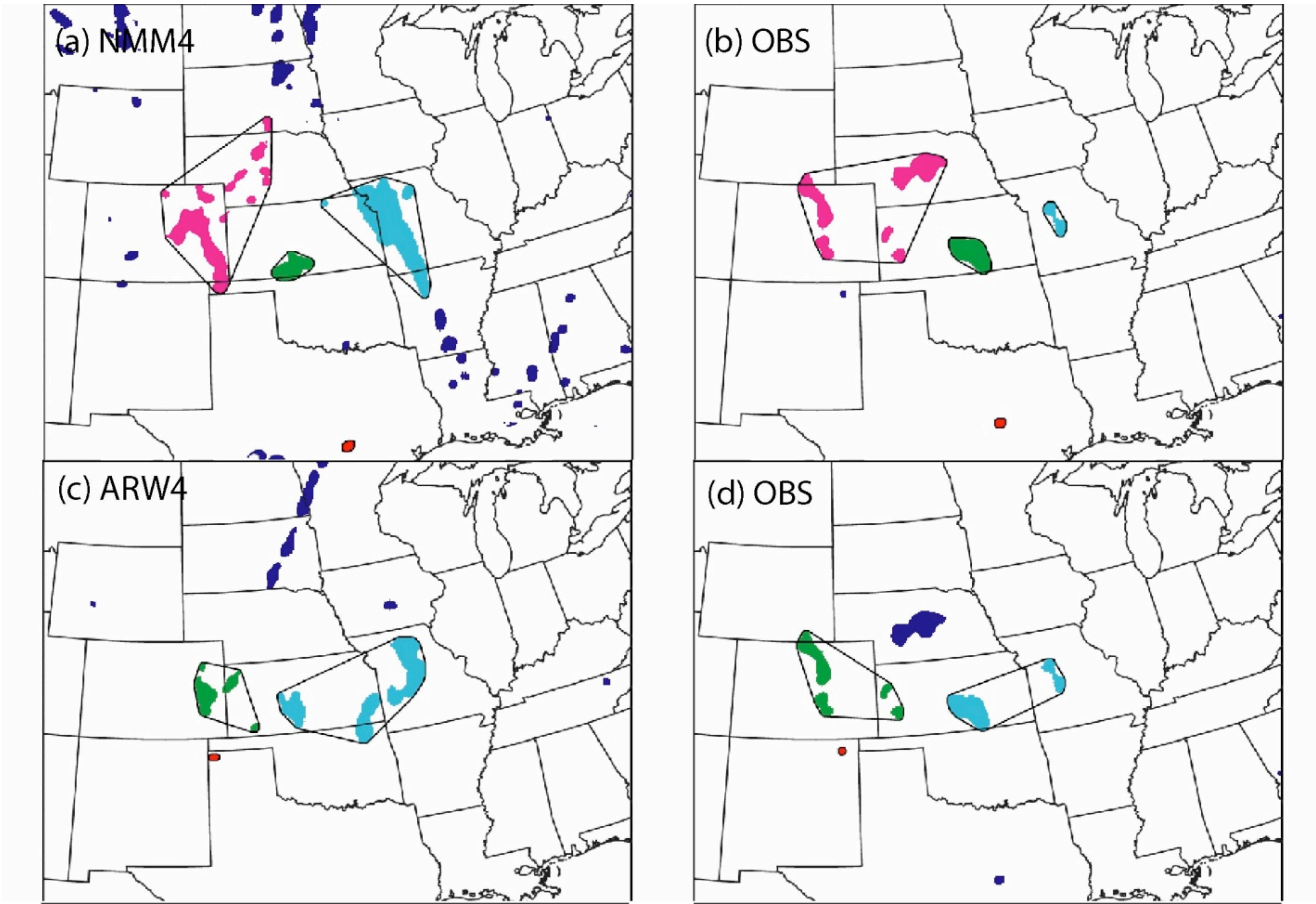
MMI as function of convolution radius and threshold



MMIF for 9 cases



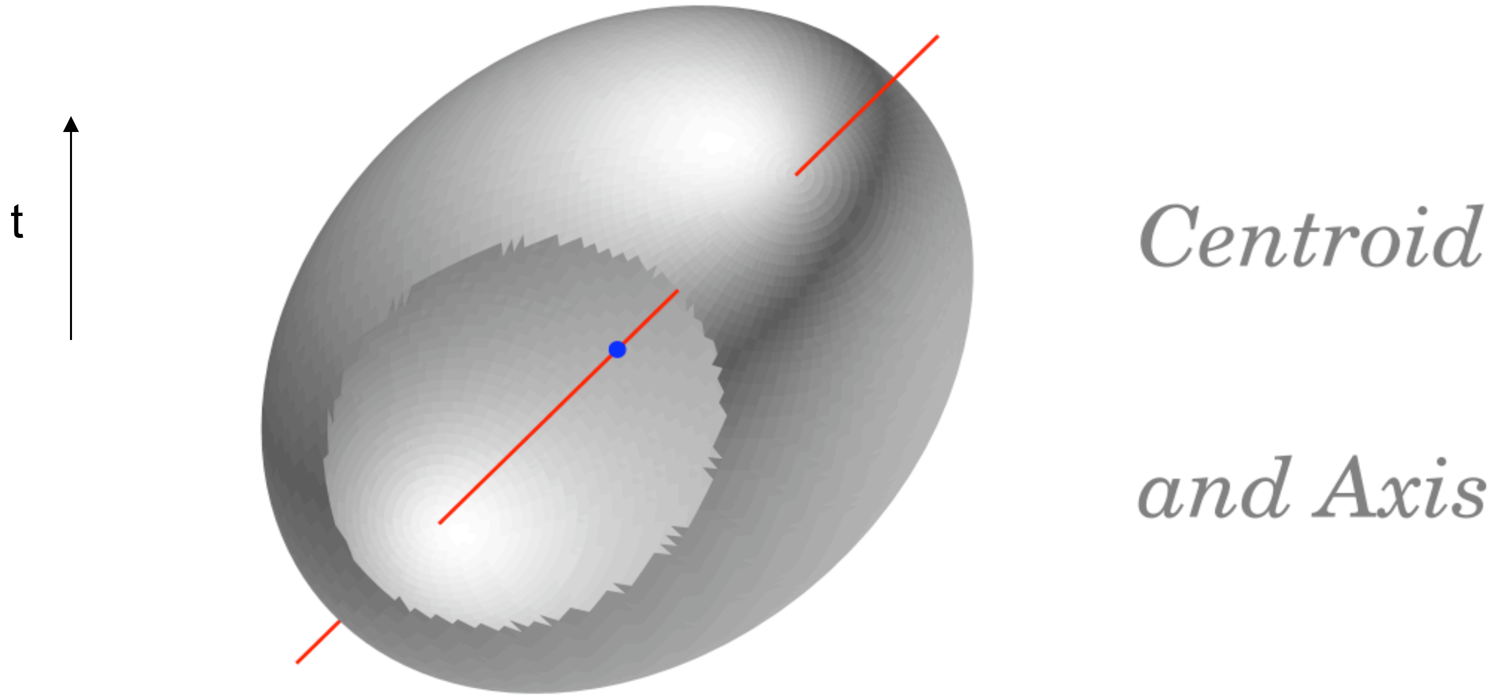
June 4, 2005



Results for 32 Cases

R=10	**0.63/0.70** *(292)*	**0.67/0.68** *(173)*	**0.59/0.62** *(95)*	*R=10*	**0.58/0.73** *(459)*	**0.55/0.69** *(315)*	**0.52/0.63** *(155)*
R=5	**0.66/0.70** *(690)*	**0.65/0.68** *(435)*	**0.66/0.67** *(263)*	*R=5*	**0.62/0.73** *(1027)*	**0.60/0.72** *(752)*	**0.56/0.68** *(414)*
	T=1. 5	*T=3*	*T=6*		*T=1. 5*	*T=3*	*T=6*
ARW4				NMM4			
MMIF/MMIO (*number of objects*)							

Rain Systems (x,y,t)



Angle the axis makes with the (x,y) plane determines the system speed

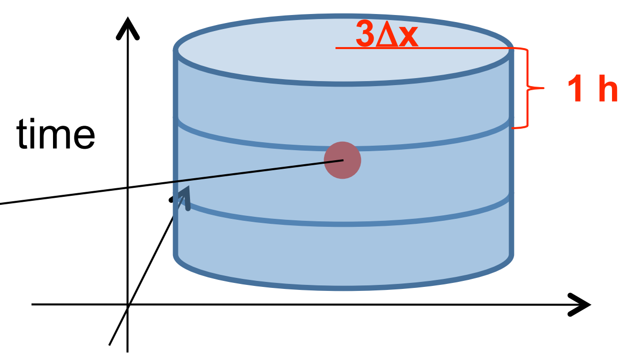
Object Identification in 3-D

- Begin with ARW (4-km) and Stage IV (4-km) hourly precipitation accumulation data.

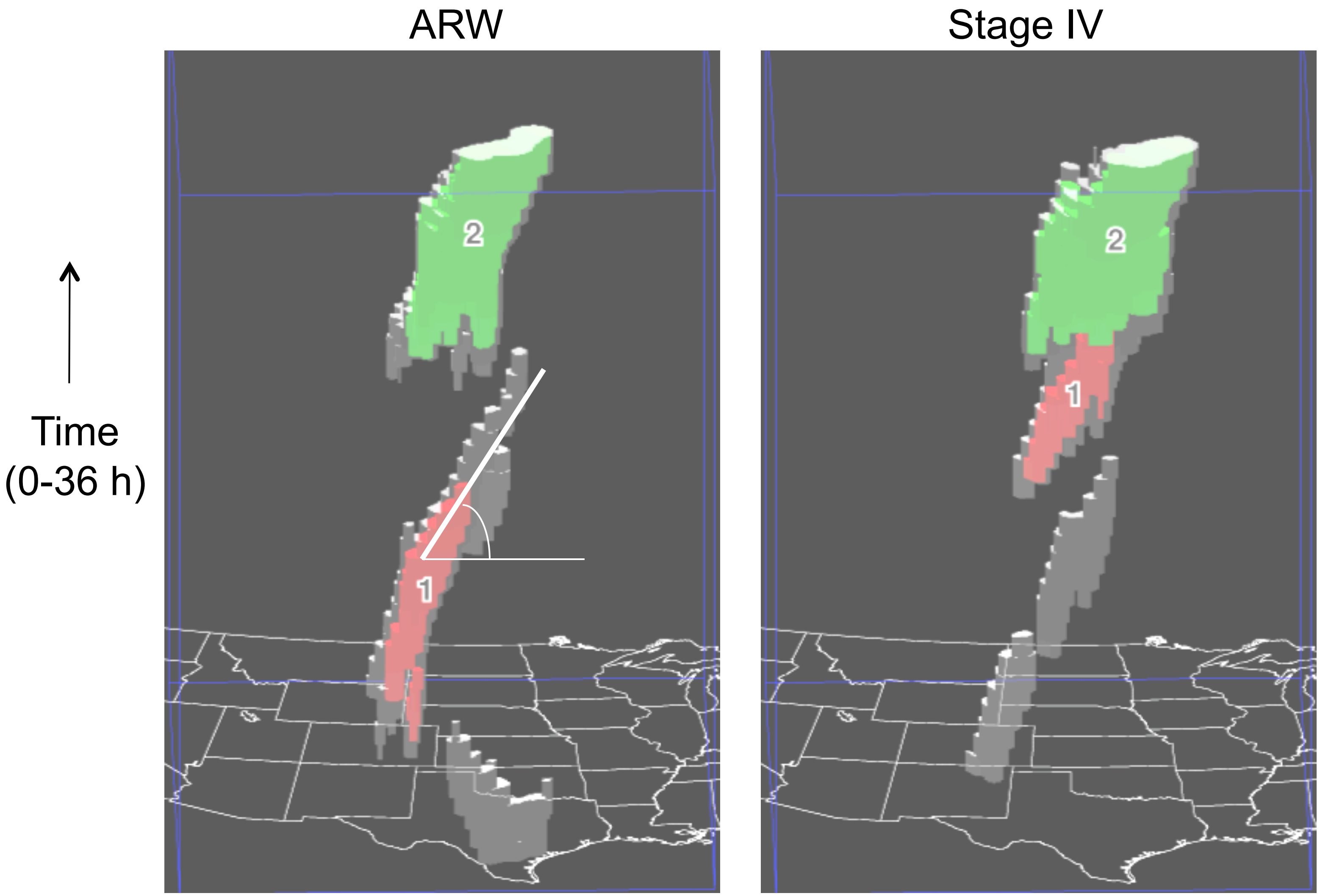
- Coarsen both to identical grid of 12-km spacing

- Apply convolution (smoothing) and filtering in 3-D
    - $3\Delta x$, ±1-h "cylindrical" convolution
    - Threshold = 2 and 4 mm/h

Replace value of rainfall at central point with average rainfall within cylinder



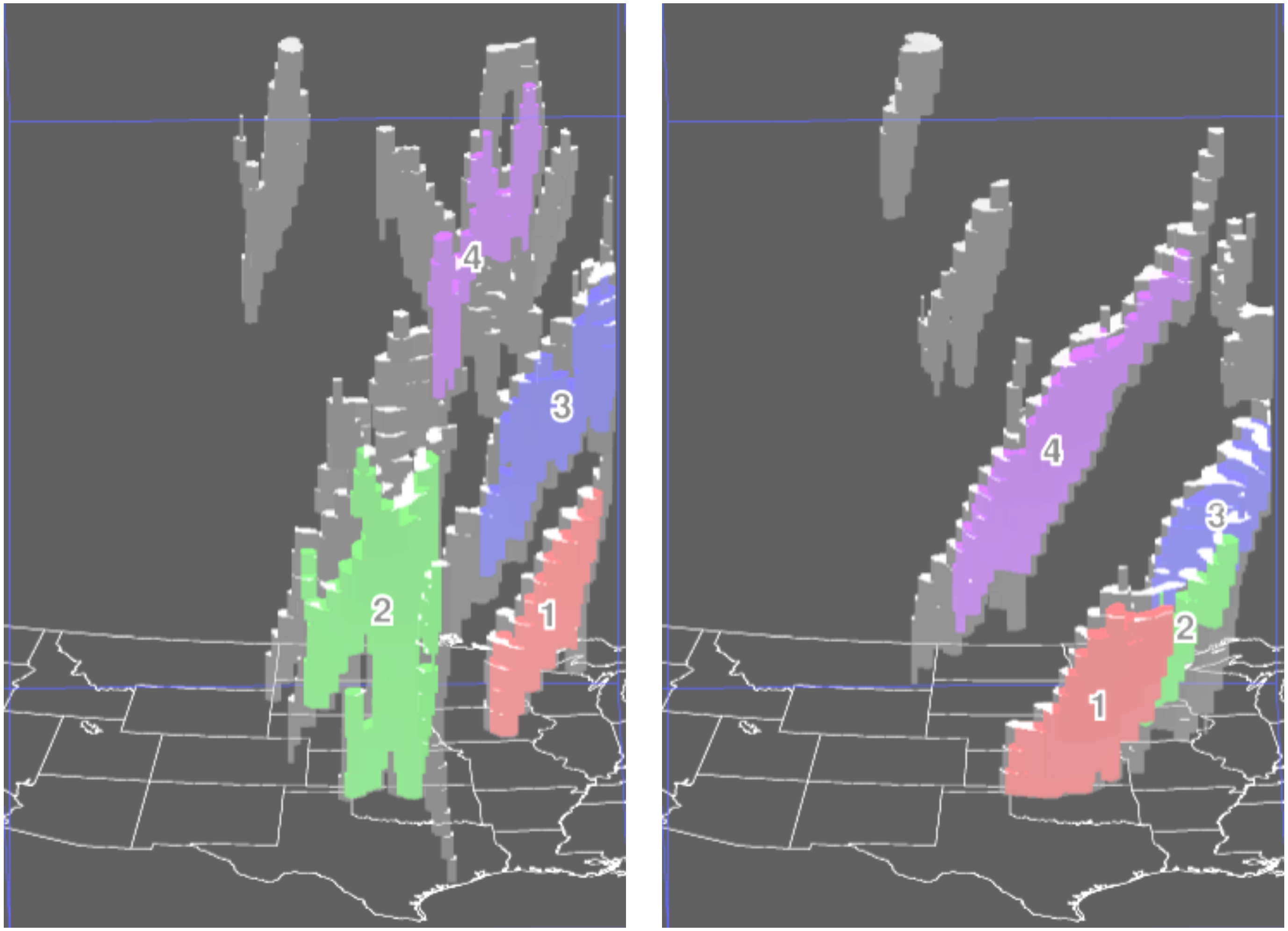
IHOP, June 15, 2002



Colors do not indicate matching

IHOP, June 10, 2002

Time
(0-36 h)

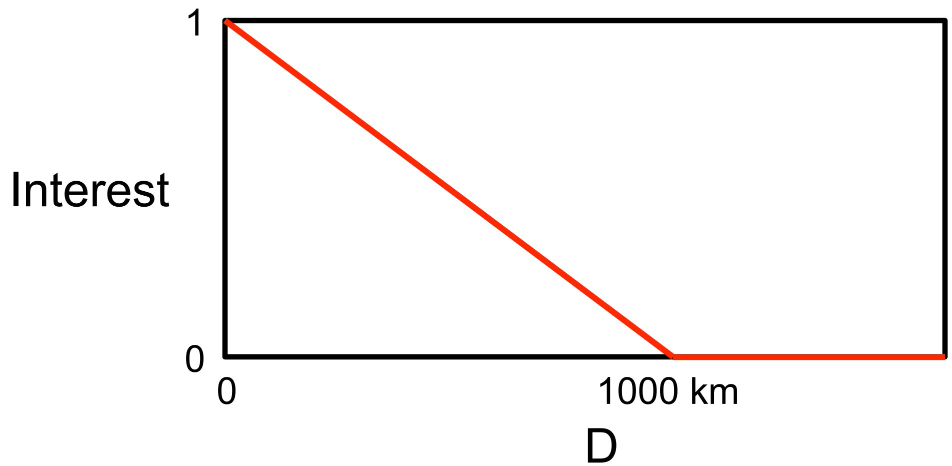


Colors do not indicate matching

Interest Maps for 3-D Objects

$$D_{i,j} = \left((x_{f_i} - x_{o_j})^2 + (y_{f_i} - y_{o_j})^2 + c^2 (t_{f_i} - t_{o_j})^2 \right)^{\frac{1}{2}}$$

- For the i^{th} forecast object and j^{th} observed object, compute $D_{i,j}$
- Choose c=30 m/s (3 h ~ 300 km)
- Apply an interest map to D
- Compute an interest for each (forecast, observed) object pair



The Interest Matrix

Observed Object

Forecast Object

	1	2	3
1	0.06	0.00	0.00
2	0.14	**0.67**	0.00
3	0.00	0.27	0.00
4	0.00	0.00	**0.72**

- MMIF = 0.47
- MMIO = 0.67
- MMI = 0.57

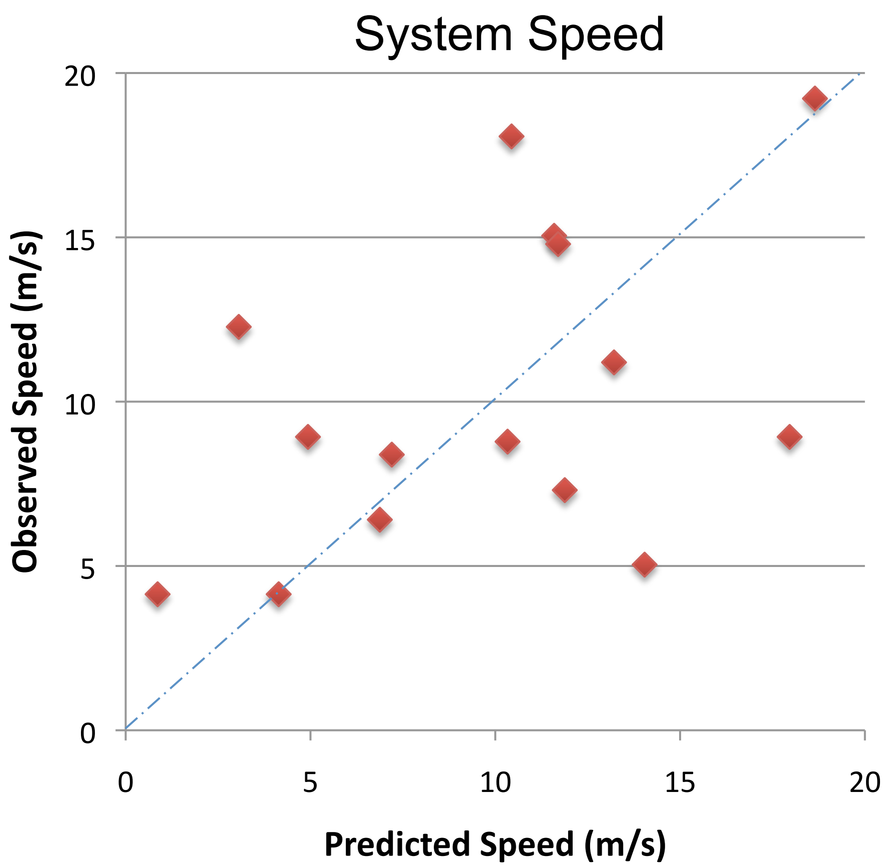
Results

Including systems with duration > 300 grid volumes*

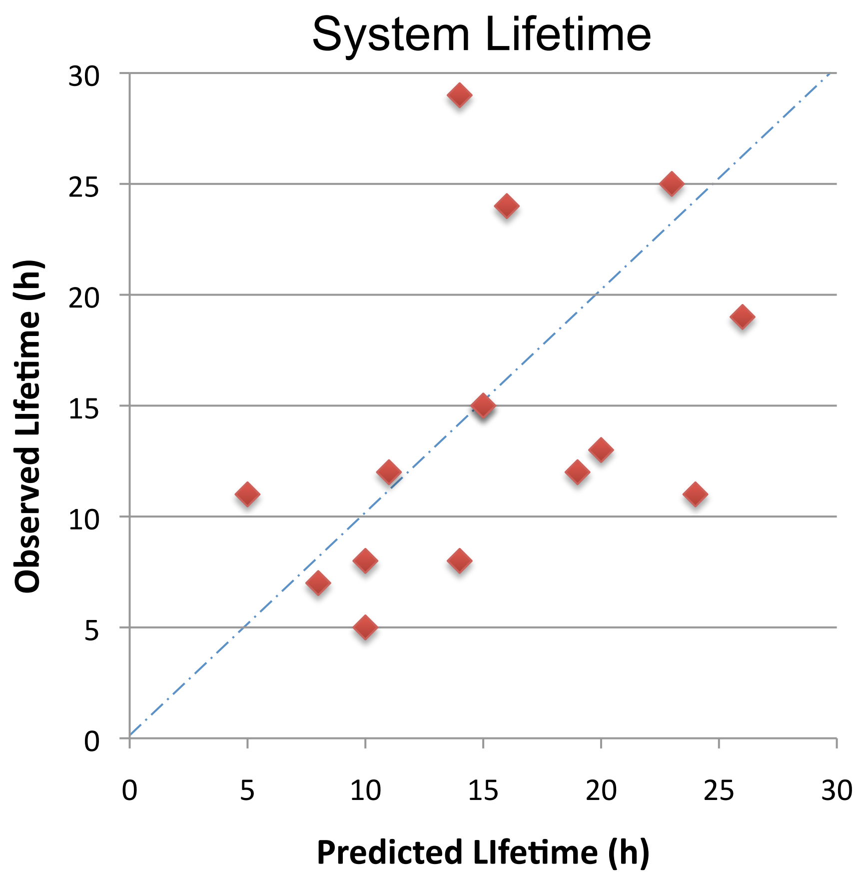
Date of initialization (00 UTC)	MMI (T=2)	MMI (T=4)
10 June	0.56	**0.75**
11 June	**0.42**	0.59
12 June	**0.75**	**0.70**
13 June	**0.34**	0.56
15 June	0.57	0.50

*a rain system 120 km x 120 km x 3 h would be 300 grid volumes

Attributes of Rain Systems



No obvious bias
Limited skill



Small high bias in
predicted lifetime

Summary

- MODE: ICP cases
  - Interest matrices
    - Fuzzy-logic system for determining match likelihood
    - Statistics of interest matrix (MMI, etc.)
  - Able to distinguish model predictions (some agreement with subjective eval)
  - Can MODE be hedged?

- Extension to 3-D (time dimension)
  - Evaluate system movement, start, lifetime
  - Some geometric considerations extend from 2-D
  - Issue of scaling of space and time