Diagnostic Verification Measures Associated with Object-Oriented Verification Approaches

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Goals

- Now that we have some ability to obtain diagnostic information, what shall we do with it?
- Appropriate form and use of the information depend on the user (manager, forecaster, model developer, water manager, airline dispatcher, ...)
- Output of a verification system should fit the perspective of the user

Goals

- In this case, the user is

ME

- My perspective/goals are to
  - *Better understand how (well) the verification system works*
  - *Explore the output of the system from a variety of different angles*
  - *Start developing alternative ways of summarizing it that would be beneficial for other types of (real) users*

The story so far…

Objective-oriented approach

- *Objectively identify precipitation regions/objects using a convolution/thresholding process*
- *Measure attributes of the precipitation areas (size, orientation, precipitation intensity, etc.)*
- *Use attributes to objectively merge objects in the same field and match objects between fields*

The next chapter:

- *Compare attributes of forecast and observed regions*

Philosophy

- Avoid summary “measures” as much as possible
- Focus on distribution representations
- Define the questions that we want to answer – a “diagnostic” approach

Data

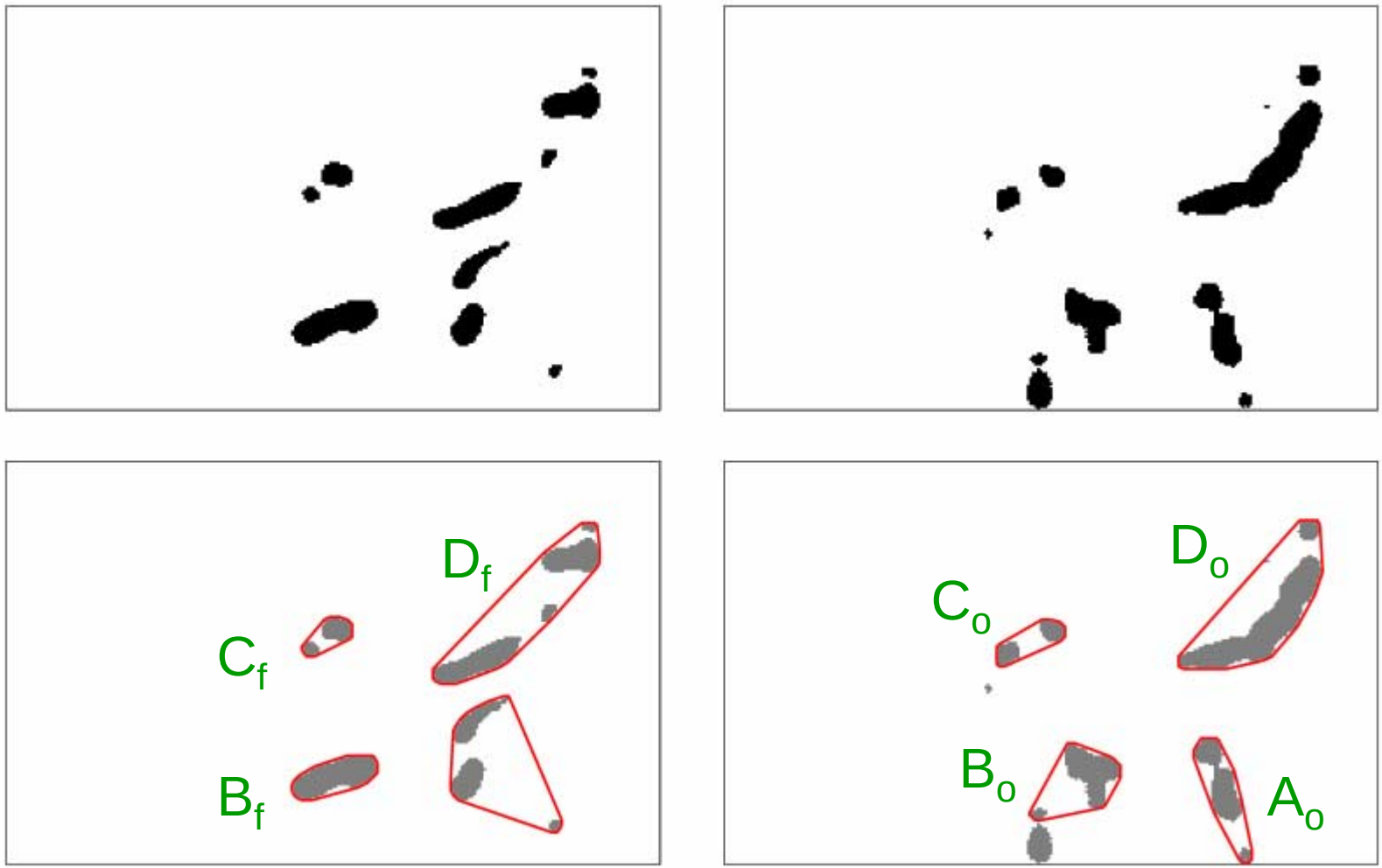
- Forecasts
  - *Weather Research and Forecasting (WRF) system*
  - *22-km horizontal resolution over the continental U.S.*
  - *Summer 2001 and 2002*
  - *Forecasts out to 48 hours, issued at 0000 UTC*
- Observations
  - *Stage IV multi-sensor (radar and rain gauge) precipitation analysis (NOAA/NCEP)*
  - *4-km grid, mapped to 22 km*

Object identification

- Convolving radius: 4 gridpoints
- Threshold: 2.5 mm
- Numbers of objects:

	West	East	Total
Stage IV	5,622	17,608	23,230
WRF	6,172	18,528	24,700
Total	11,794	36,136	47,930

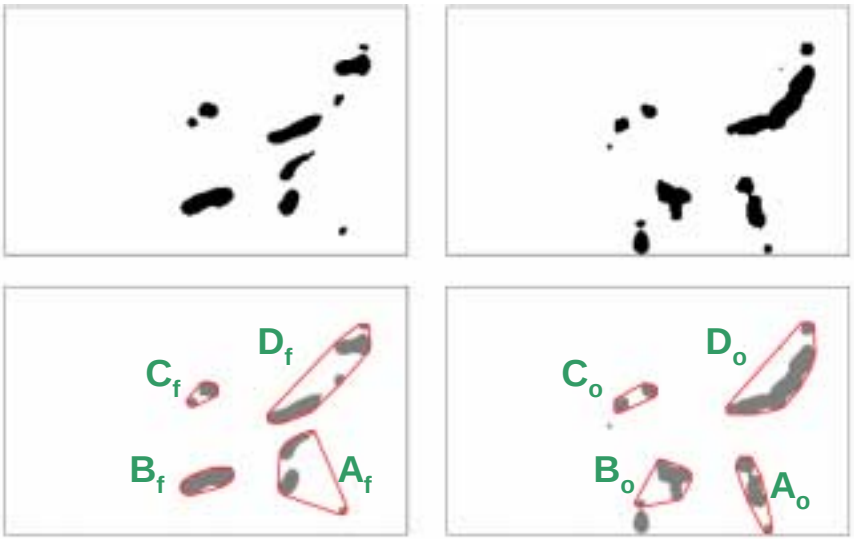
A single case



Forecasts: 12-h WRF precipitation

Obs: Stage IV precipitation

A single case cont.

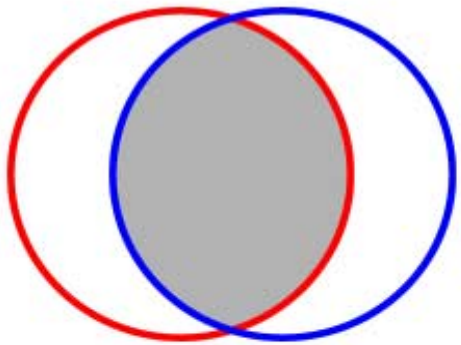


Forecast

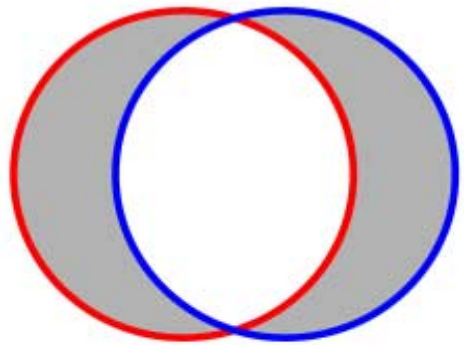
Observed

Composite object	Intersection Area (IA)	Symmetric Difference (SD) Area
A	0	638
B	100	488
C	66	134
D	259	905

Attribute	WRF	Stage IV	Difference
Composite Objects "A"			
Centroid X	187	197	-10
Centroid Y	44	31	13
Intensity (0.50)	4.7	2.5	2.2
Intensity (0.90)	8.5	13.9	-5.4
Area	319	319	0
Composite Objects "B"			
Centroid X	130	144	-14
Centroid Y	36	36	0
Intensity (0.50)	4.7	2.0	2.7
Intensity (0.90)	8.7	9.7	-1.0
Area	355	333	22
Composite Objects "C"			
Centroid X	128	121	7
Centroid Y	93	90	3
Intensity (0.50)	4.0	2.4	1.6
Intensity (0.90)	8.5	11.3	-2.8
Area	126	140	-14
Composite Objects "D"			
Centroid X	205	215	-10
Centroid Y	102	100	2
Intensity (0.50)	3.8	3.8	0
Intensity (0.90)	7.4	13.8	-6.4
Area	585	838	-253

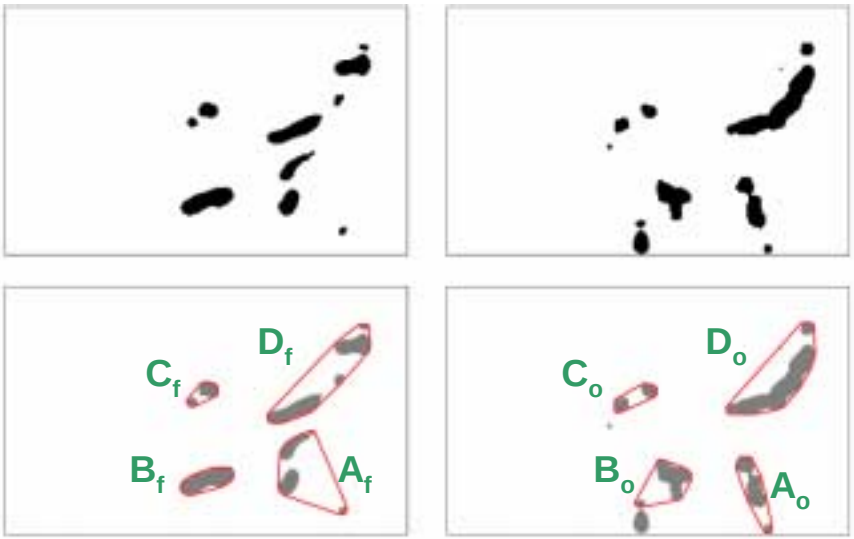


Intersection



Symmetric Difference

A single case cont.



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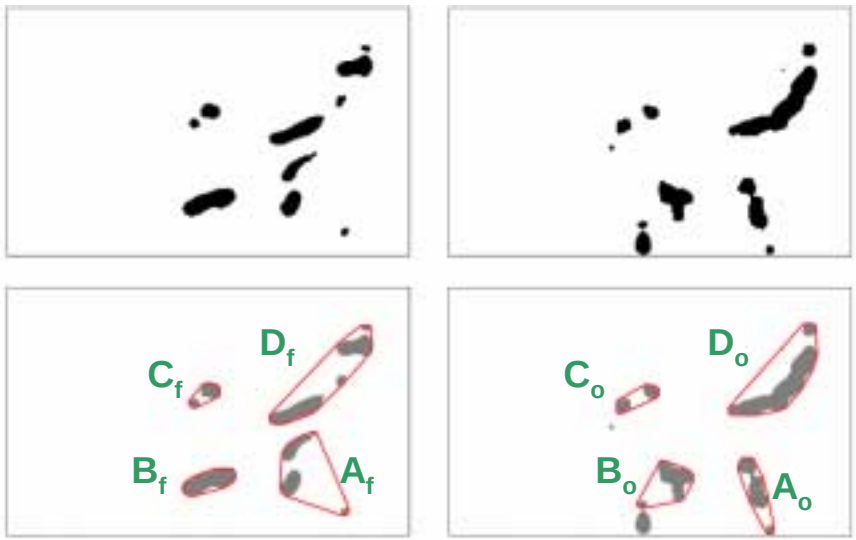
A single example: Summary

1. All forecast objects (except C) are located too far West

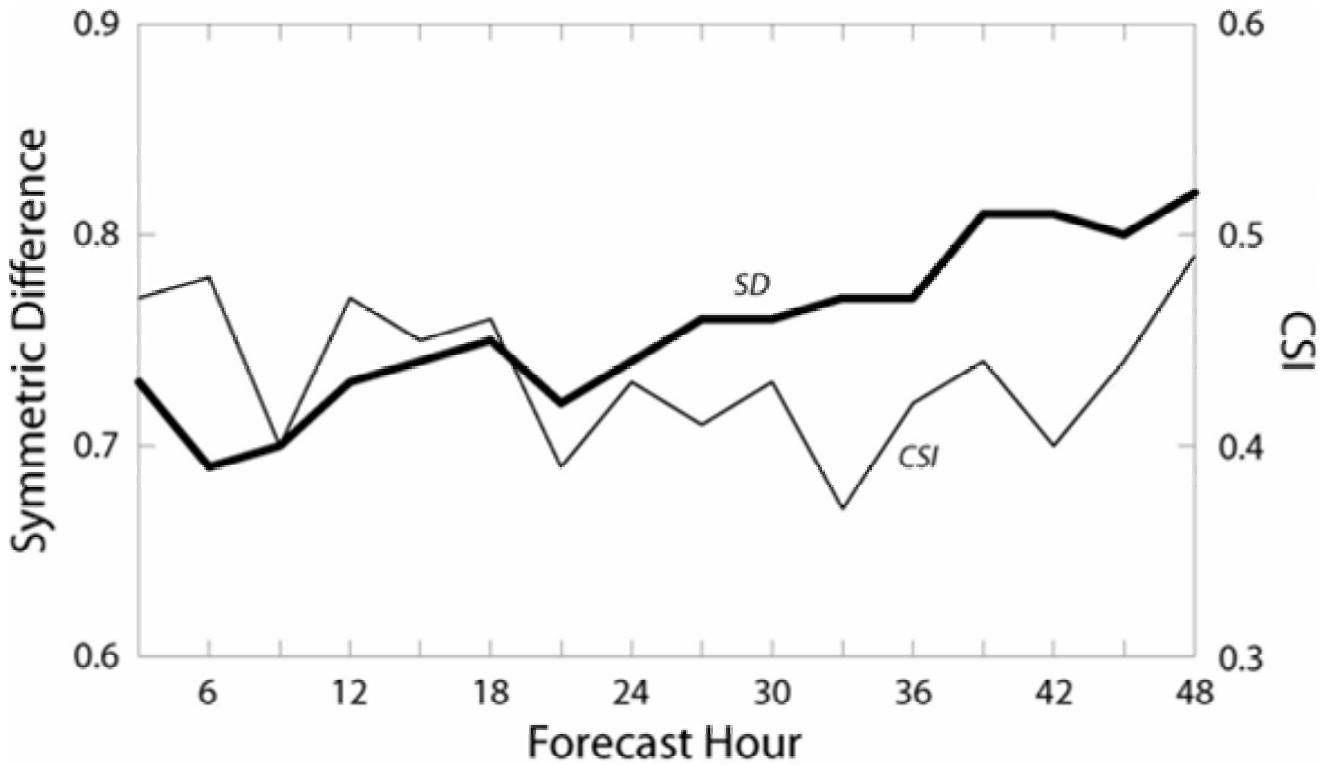


2. All forecast objects (except B) are located slightly too far North
3. Forecast median intensity is too large
4. Forecast 0.90th intensity is too small
5. Forecasts C and D are too small
6. Forecast B is somewhat too large
7. Two small observed objects were not matched to forecast objects

Some questions of interest

- How well are objects matched?
- How many objects are not matched (i.e., false alarms, misses)? What are the characteristics of the unmatched objects?
- Does object area vary between (a) Stage IV and WRF; (b) between East and West?
- How similar are WRF and Stage IV object sizes?
- Does precipitation intensity vary between WRF and Stage IV objects? Between East and West?
- What are the relationships between WRF and Stage IV precipitation quantiles?
- Is the intersection area dependent on lead time? Size of the object?

How well are objects matched?



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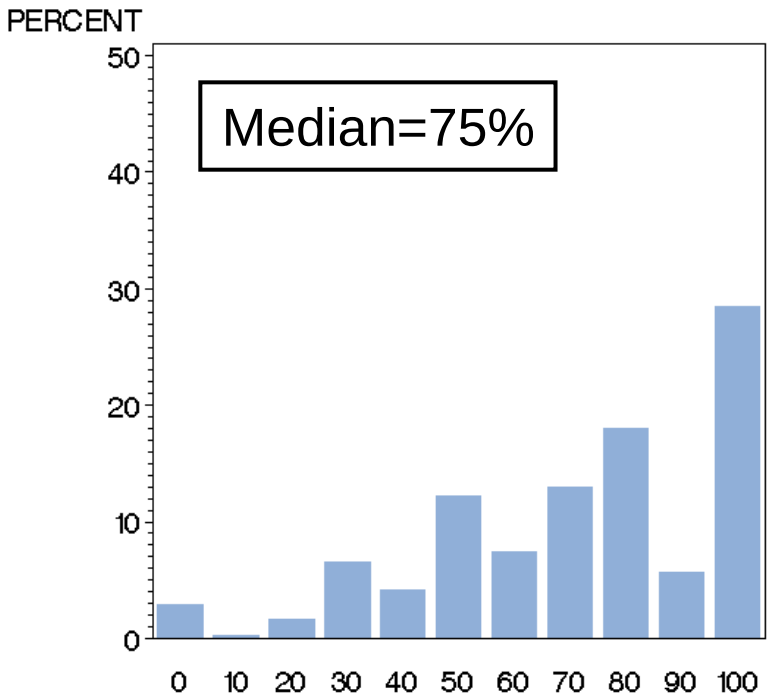
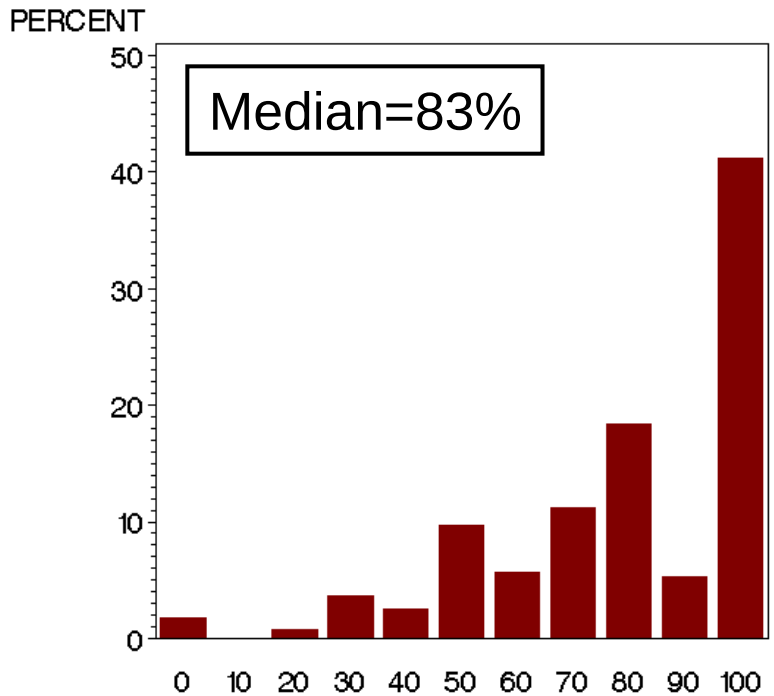
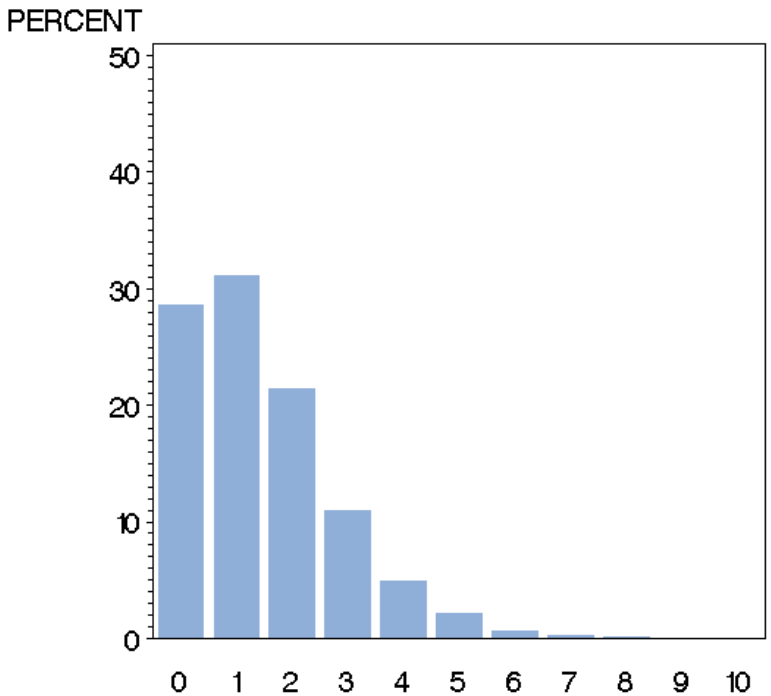


WRF: % Matched

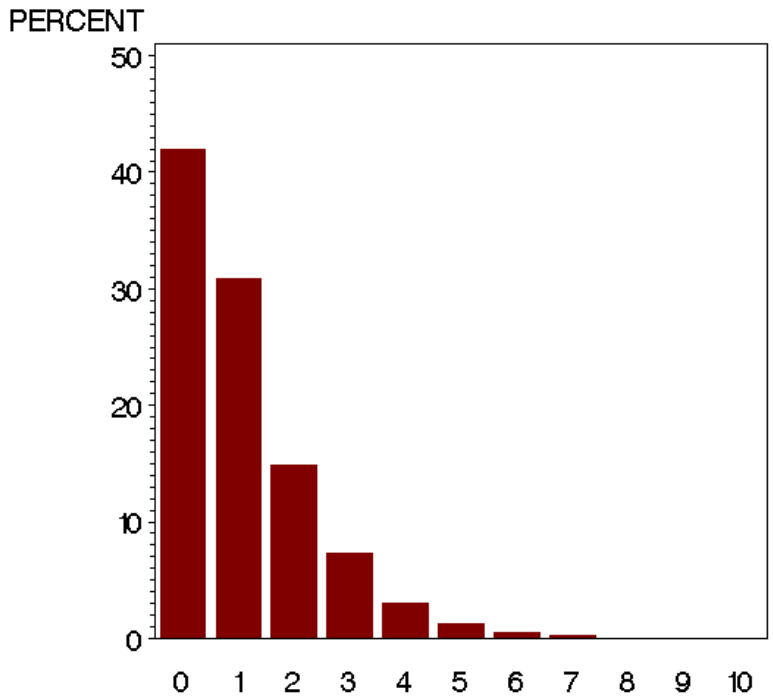


Stage IV: % Matched

How well are objects matched?



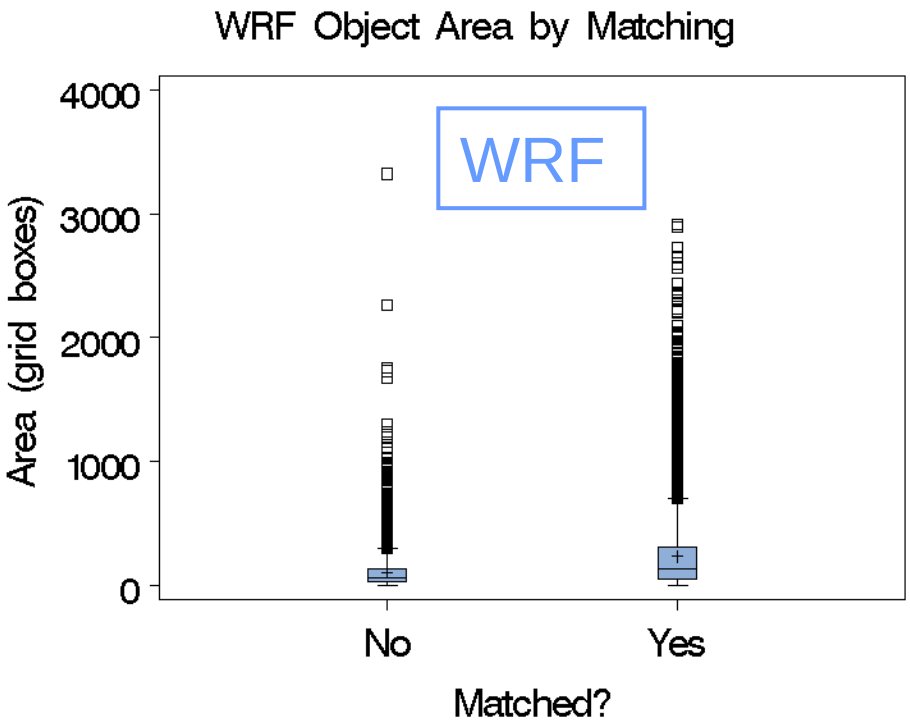
unmatched WRF objects

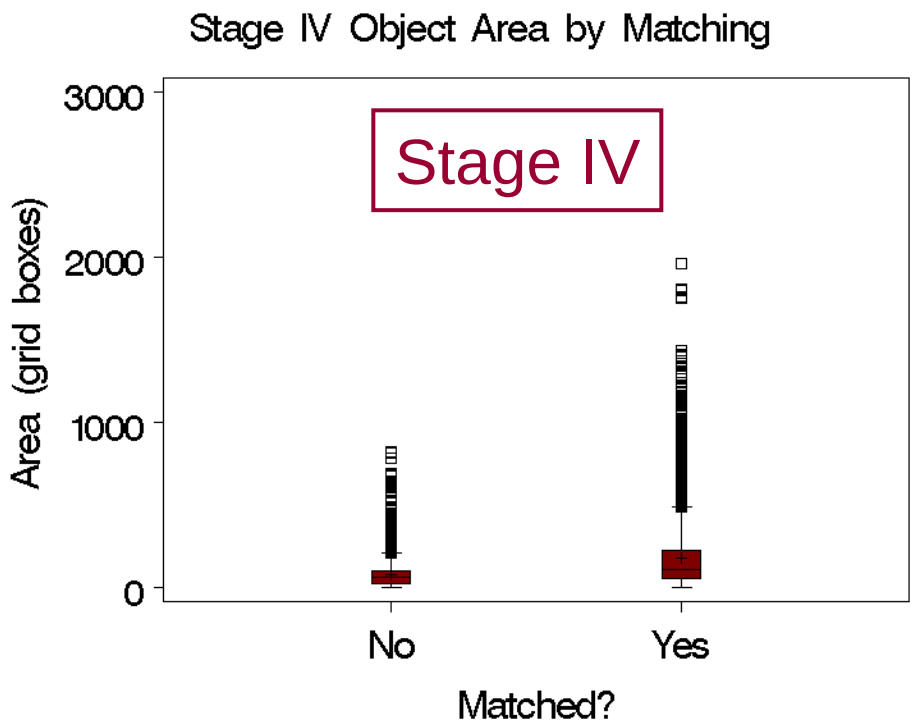


unmatched Stage IV objects

Median=1 for both

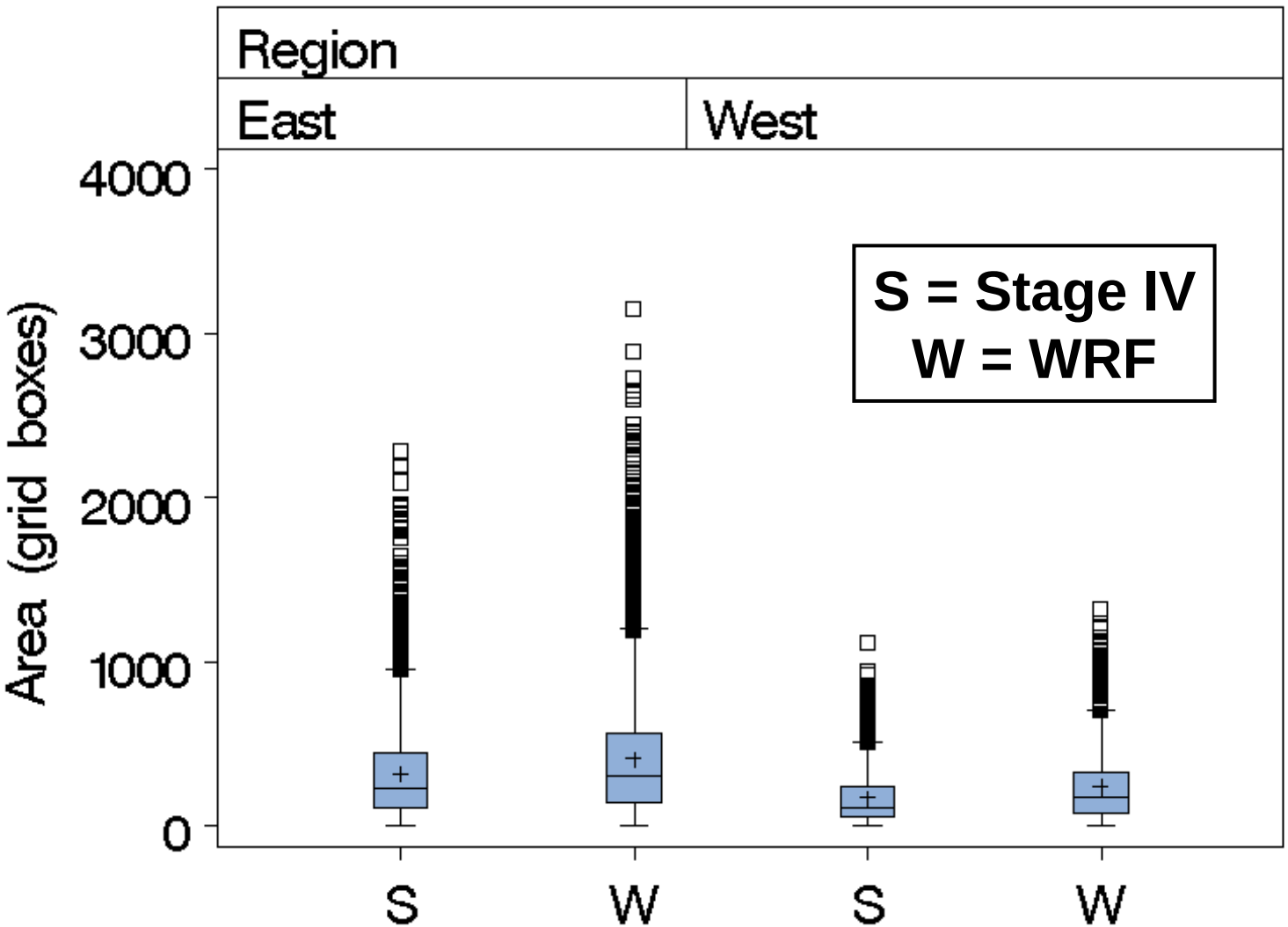
Is object size related to likelihood of matching?



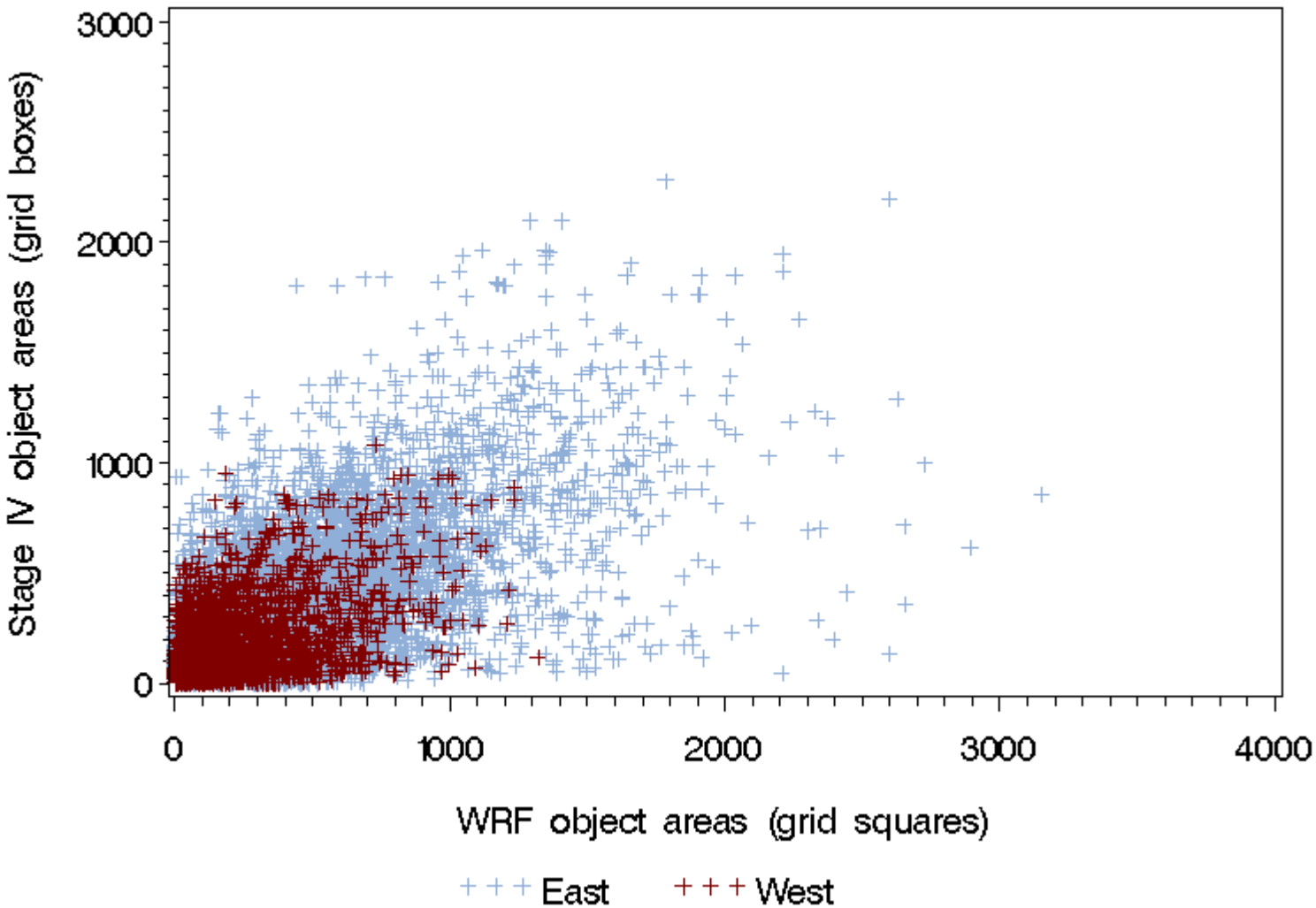


Matching vs. Object Size

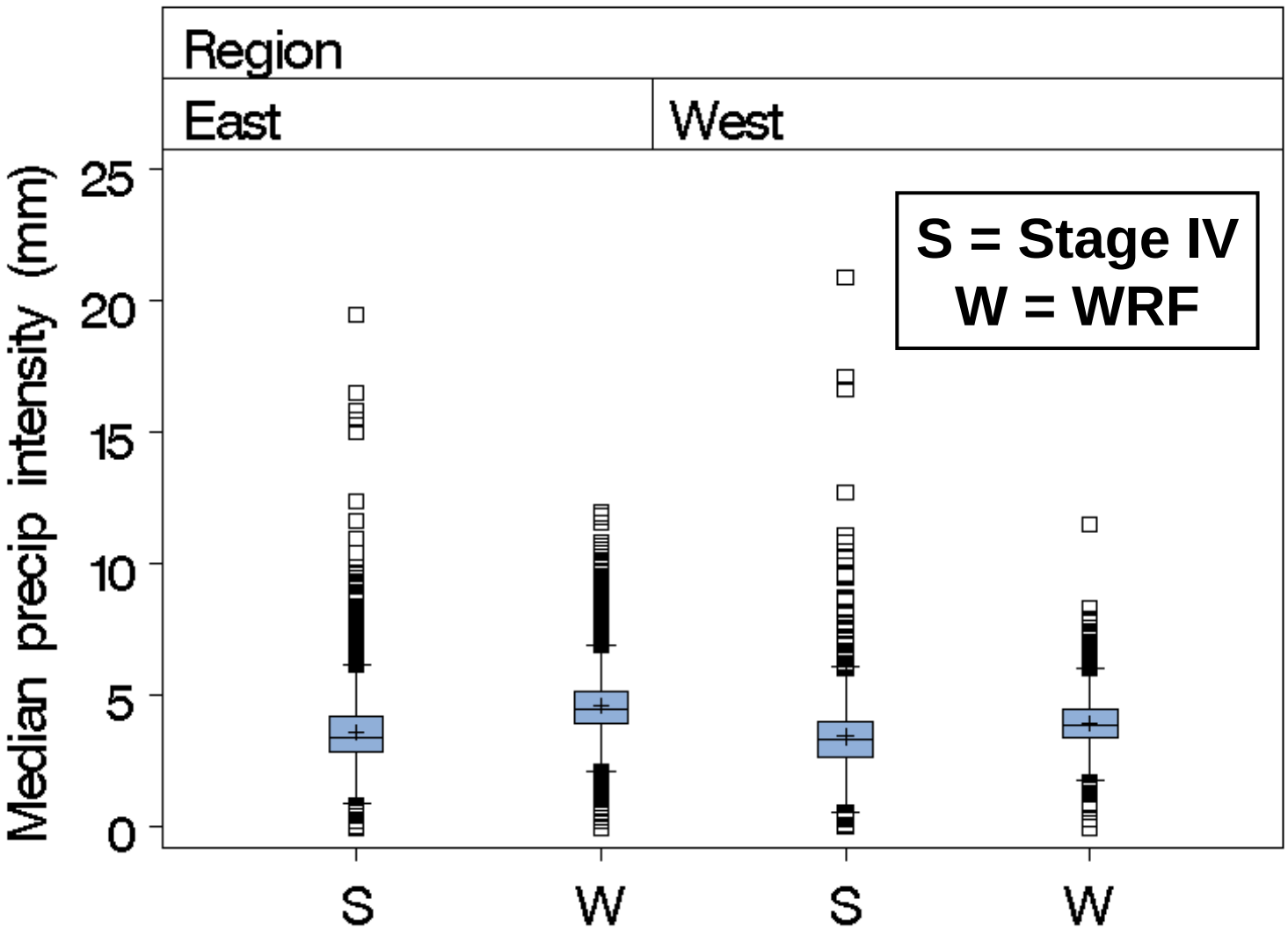
Does object area vary between (a) Stage IV and WRF; (b) between East and West?



How similar are WRF and Stage IV object sizes?



Does precipitation intensity vary between WRF and Stage IV objects? Between East and West?



Median precip intensity

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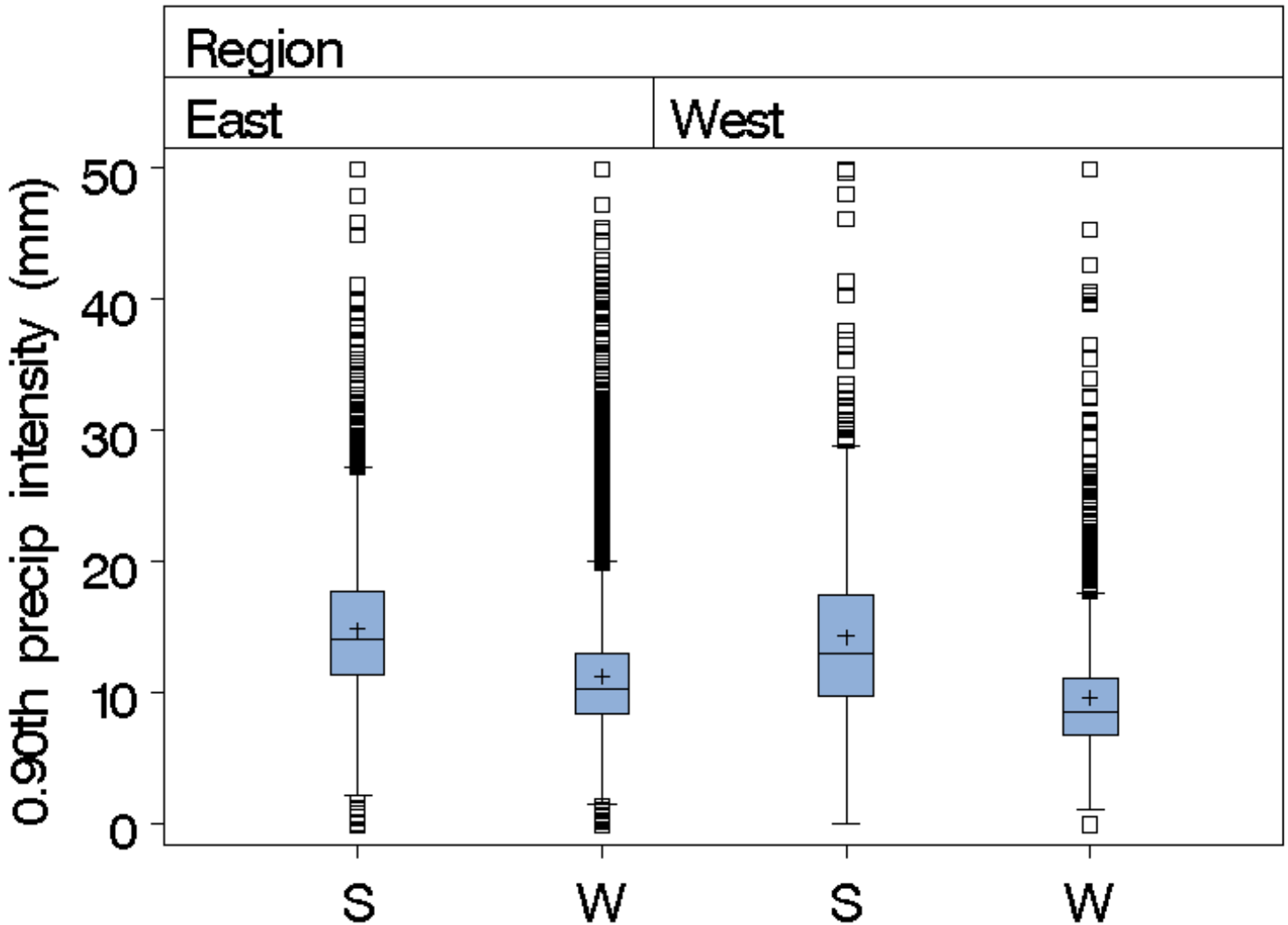
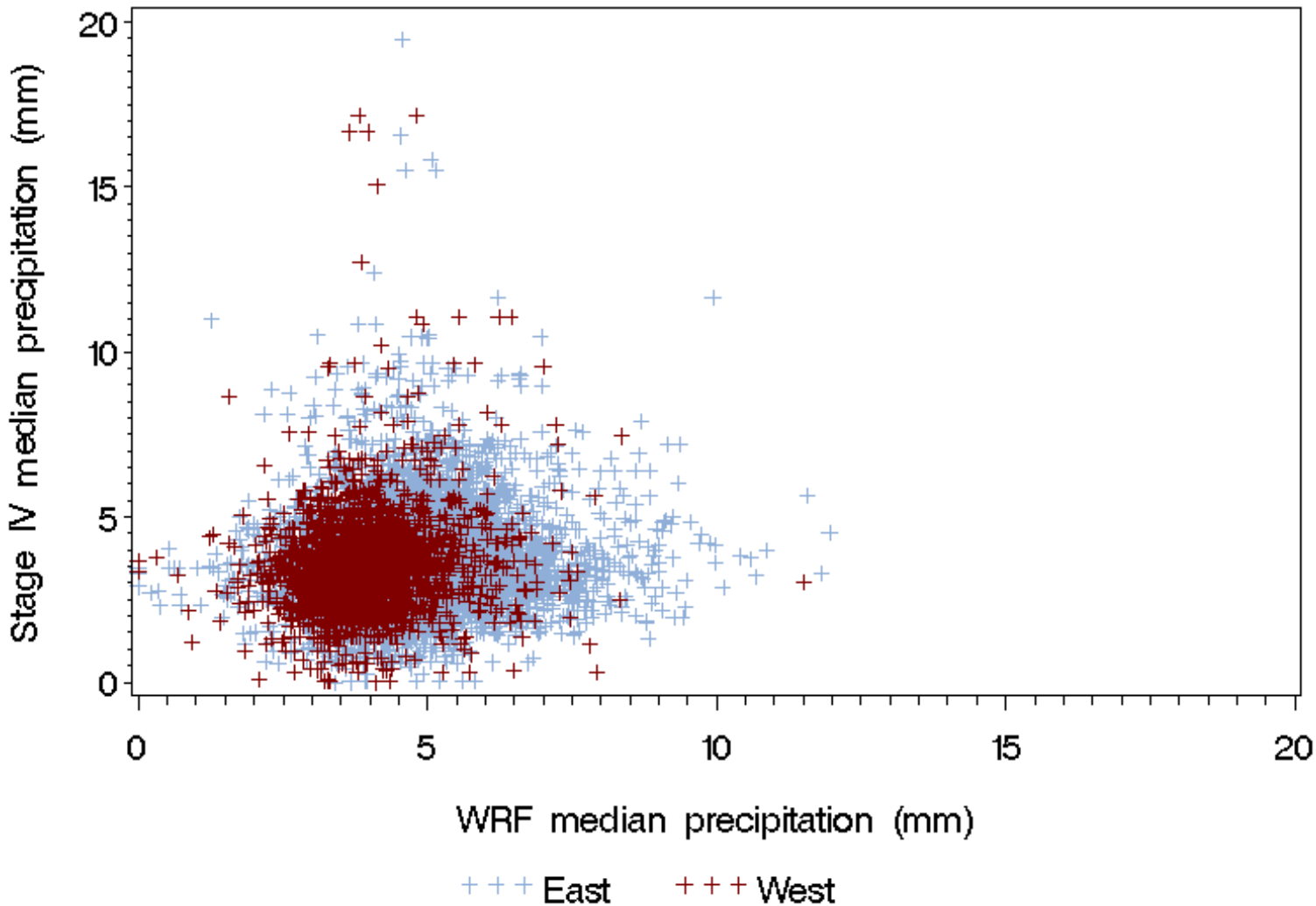


0.90th precip intensity

S = Stage IV
W = WRF

What are the relationships between WRF and Stage IV precipitation quantiles?



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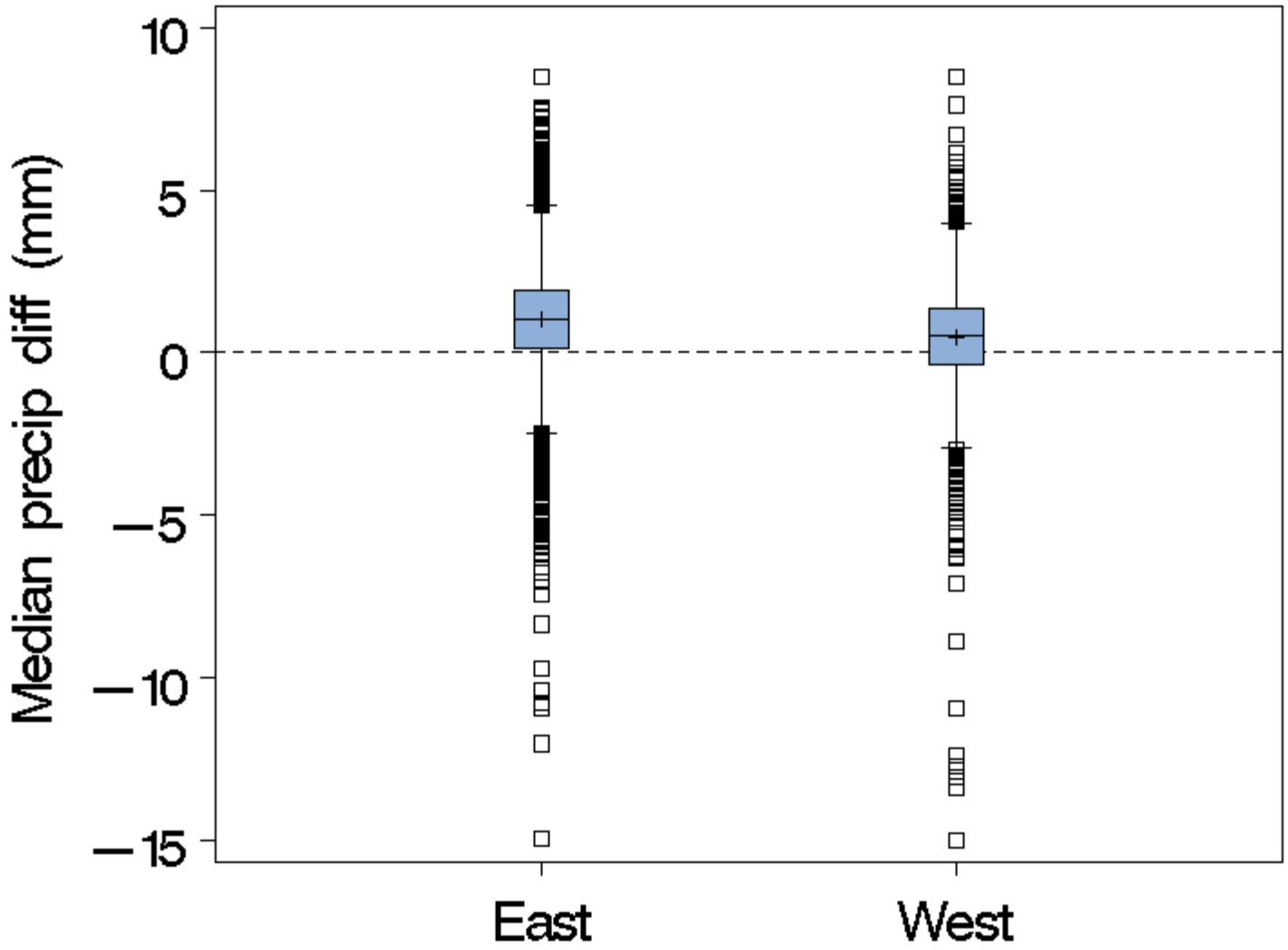

Summary/Conclusions

- Object-oriented verification approach opens up a wealth of things to examine and investigate – maybe too many!
- Focusing on the questions/attributes of interest to specific users will make this approach most meaningful

  Examples:

  Water managers – total watershed precipitation

  Aviation flight managers – N-S extent of lines of storms

Future work

- “Verify” the verification
- Consider additional attributes (e.g., total object precipitation)
- Examine other types of forecasts (nowcasts, human-generated convective forecasts)
- Develop evaluation approaches that are meaningful to specific users