Eric Gilleland

Research Applications Laboratory, National Center for Atmospheric Research

Co-authors: Gregor Skok, Barb Brown, Barbara Casati, Manfred Dorninger, Marion Mittermaier, Nigel Roberts, and Laurie Wilson

Spatial Forecast Verification: Putting location-based measures to the test with a new set of geometric cases

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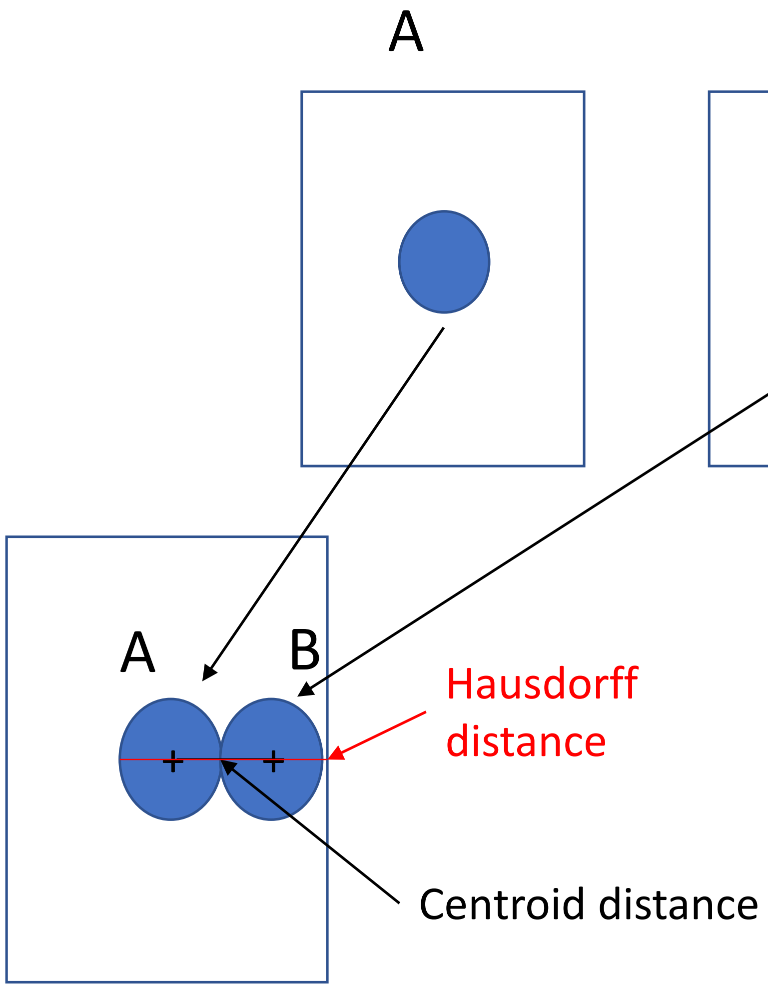
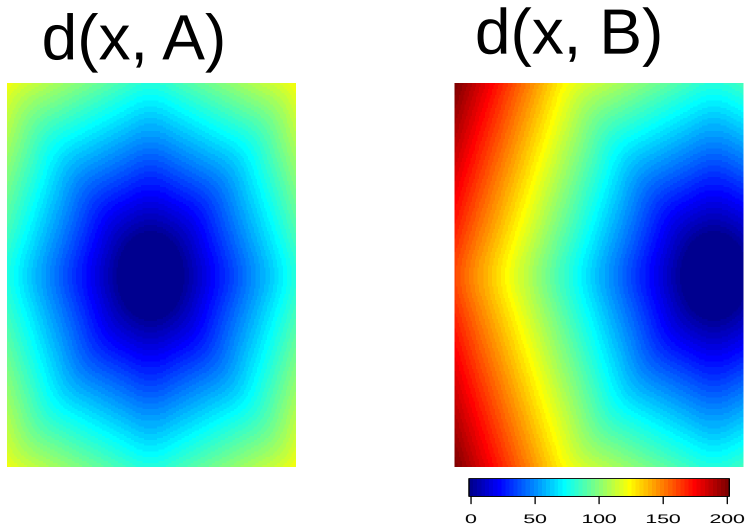
Distance maps

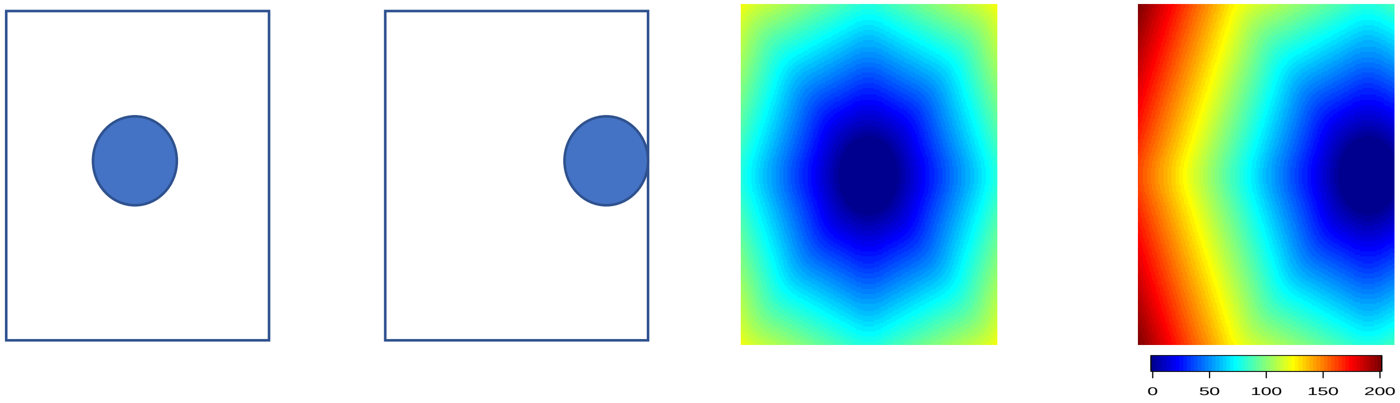


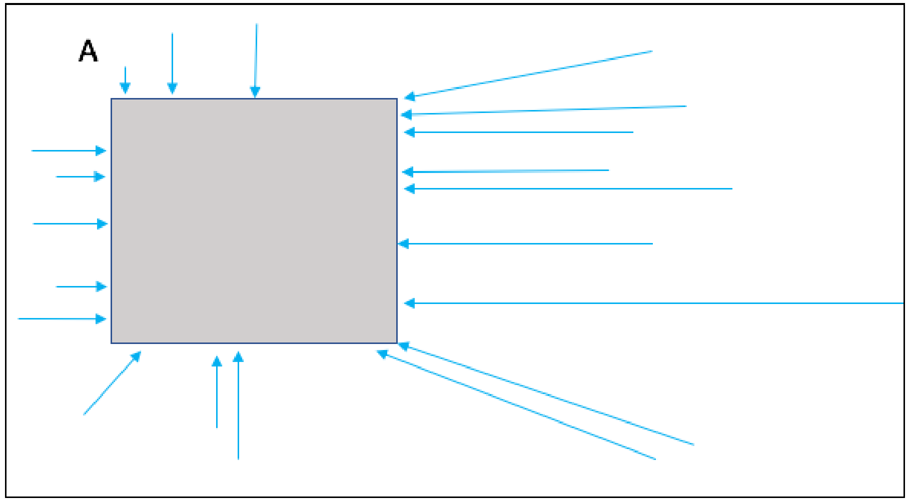


Distance maps for A and B. Note dependence on location within the domain.

Distance maps

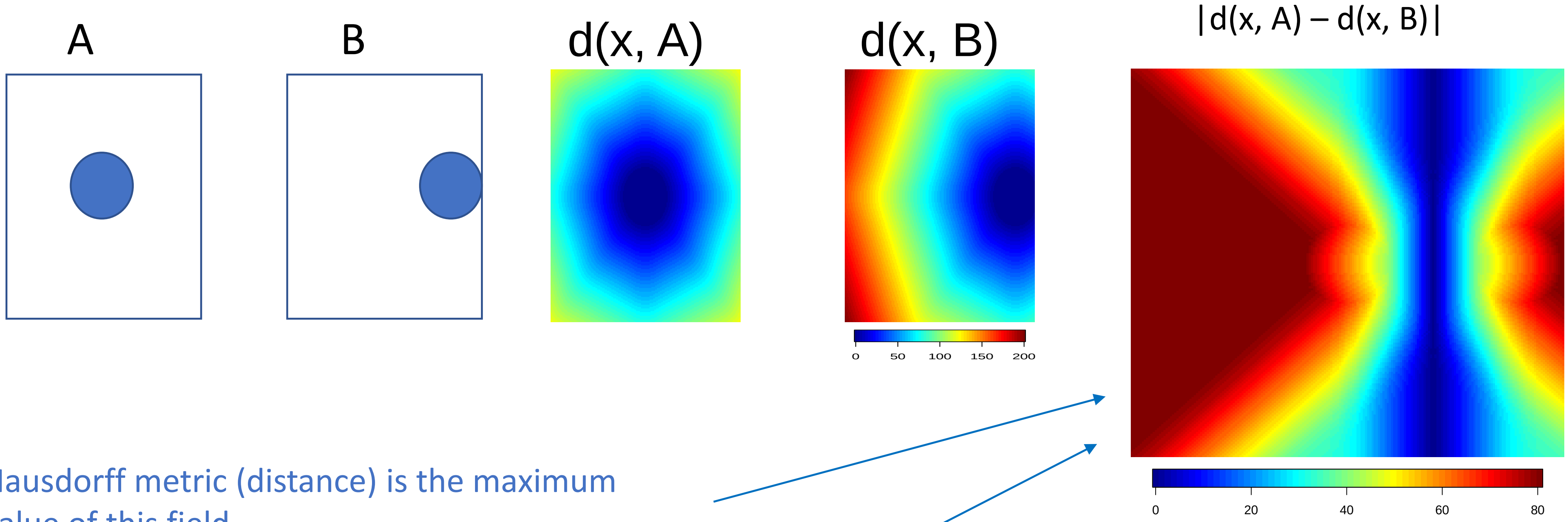
A B d(x, A) d(x, B)





Distance map is the shortest distance from ***every*** grid point in the domain to the nearest event (one-valued) grid point.

Distance maps

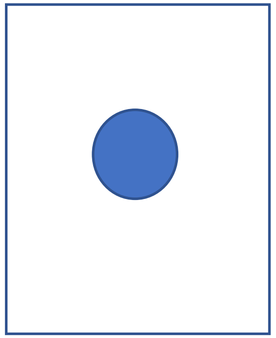


Hausdorff metric (distance) is the maximum value of this field

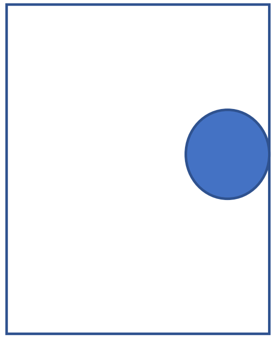
Baddeley's Δ metric is the L_p norm of this field, where the Hausdorff is the special case that $p = \infty$

Distance maps

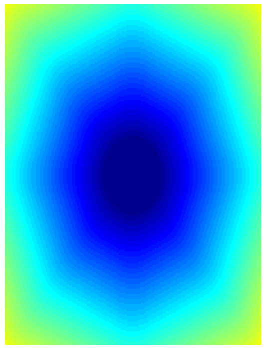
A



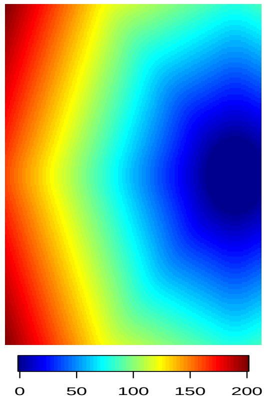
B



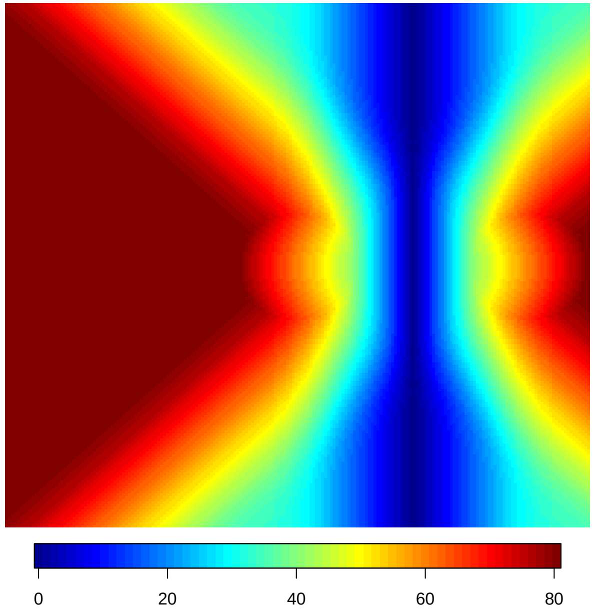
d(x, A)



d(x, B)



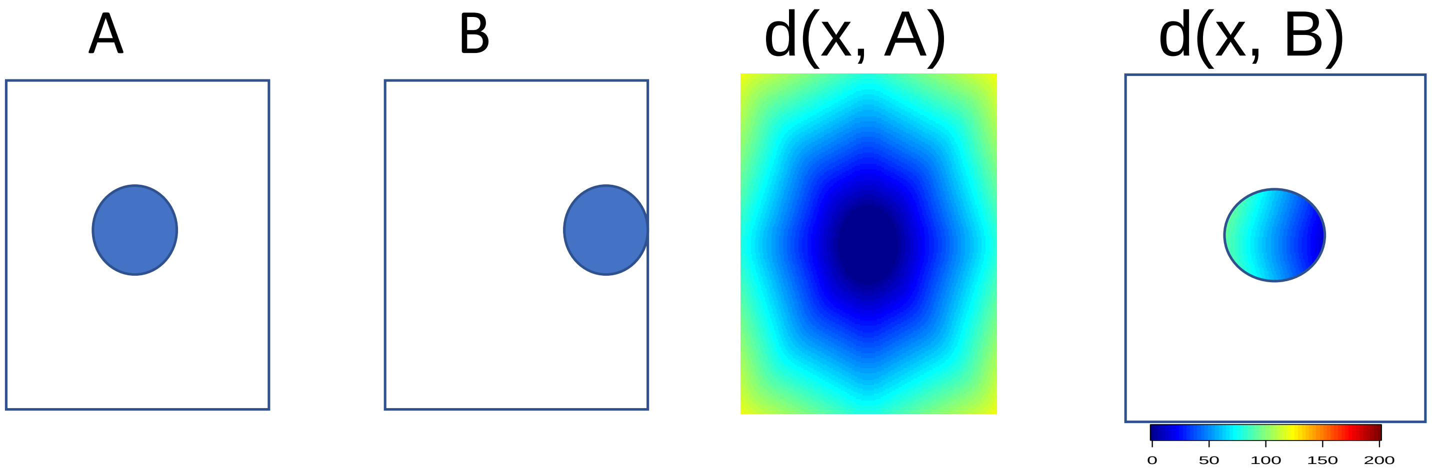
|d(x, A) – d(x, B)|



Baddeley's Δ Metric

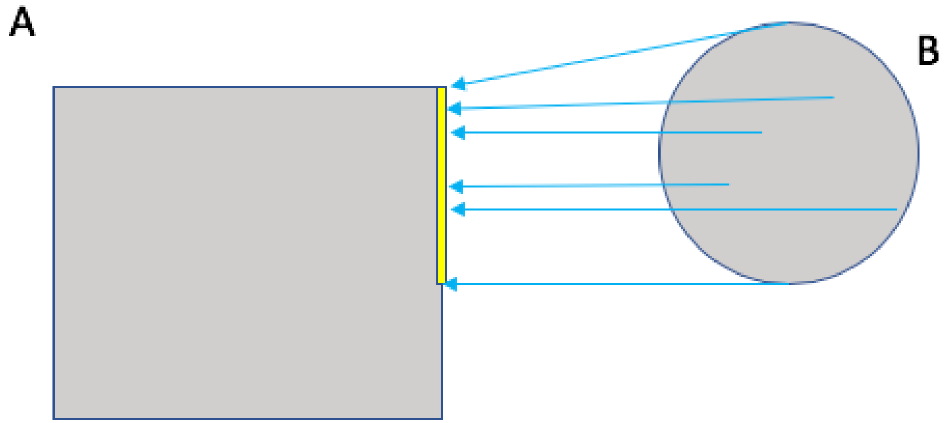
$$\Delta = \left[\frac{1}{|\mathcal{D}|}\sum_{\boldsymbol{s}\in\mathcal{D}}\left|\omega\big(d(\boldsymbol{s},A)\big) - \omega(d(\boldsymbol{s},B)\right|^{p}\right]^{1/p}$$

Distance maps



Mean Error Distance (not symmetric!)

$$\mathrm{MED}(A,B) = \frac{1}{N_B} \sum_{\boldsymbol{s} \in B} d(\boldsymbol{s}, A)$$

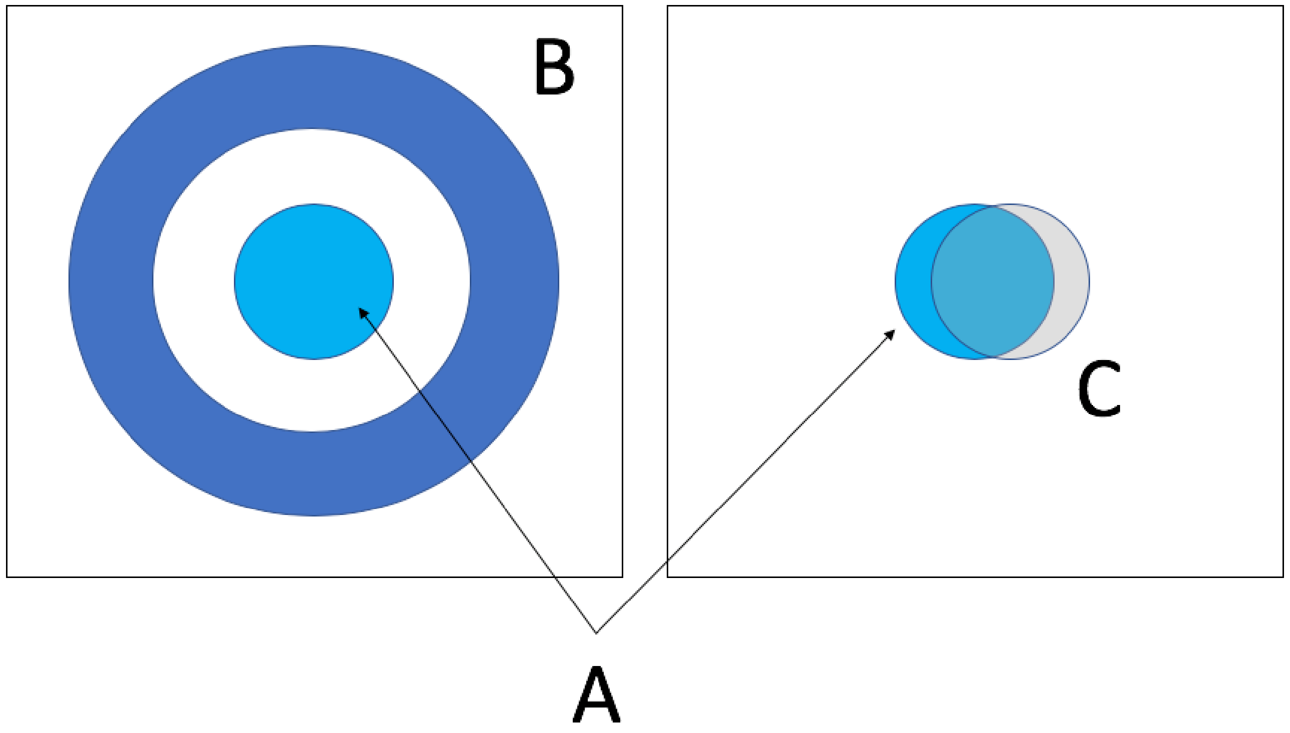


Zhu's measure is given by

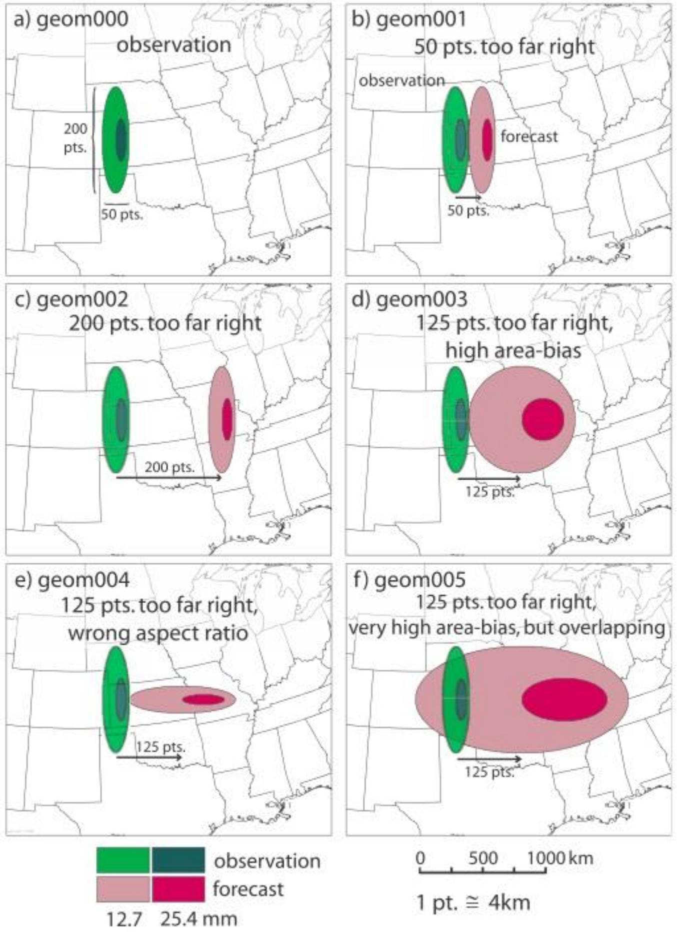
$$Z(A,B) = \lambda \cdot \sqrt{\sum_{s} \left(\mathbb{I}_A(\boldsymbol{s}) - \mathbb{I}_B(\boldsymbol{s})\right)^2} + (1-\lambda) \cdot \mathrm{MED}(A,B)$$

Properties of Distance Measures

- Want to identify how different summary measures behave for different situations.
- Here, Centroid distance (CDST) gives a perfect score of zero between A and B, but gives a higher value between A and C.
- That is, according to CDST, B is closer to A than C.



New Geometric Test Cases



These cases from the ICP were very useful in gleaning information about how spatial methods summarized/ranked different types of forecast situations. They were gridded cases based on Barb Brown's illustration of some of the challenged faced when verifying high-resolution forecasts.

But, since then many new situations have come to light that needed attention.

All subsequent cases are placed on a 200 by 200 grid.

New Geometric Test Cases

Pathological Cases

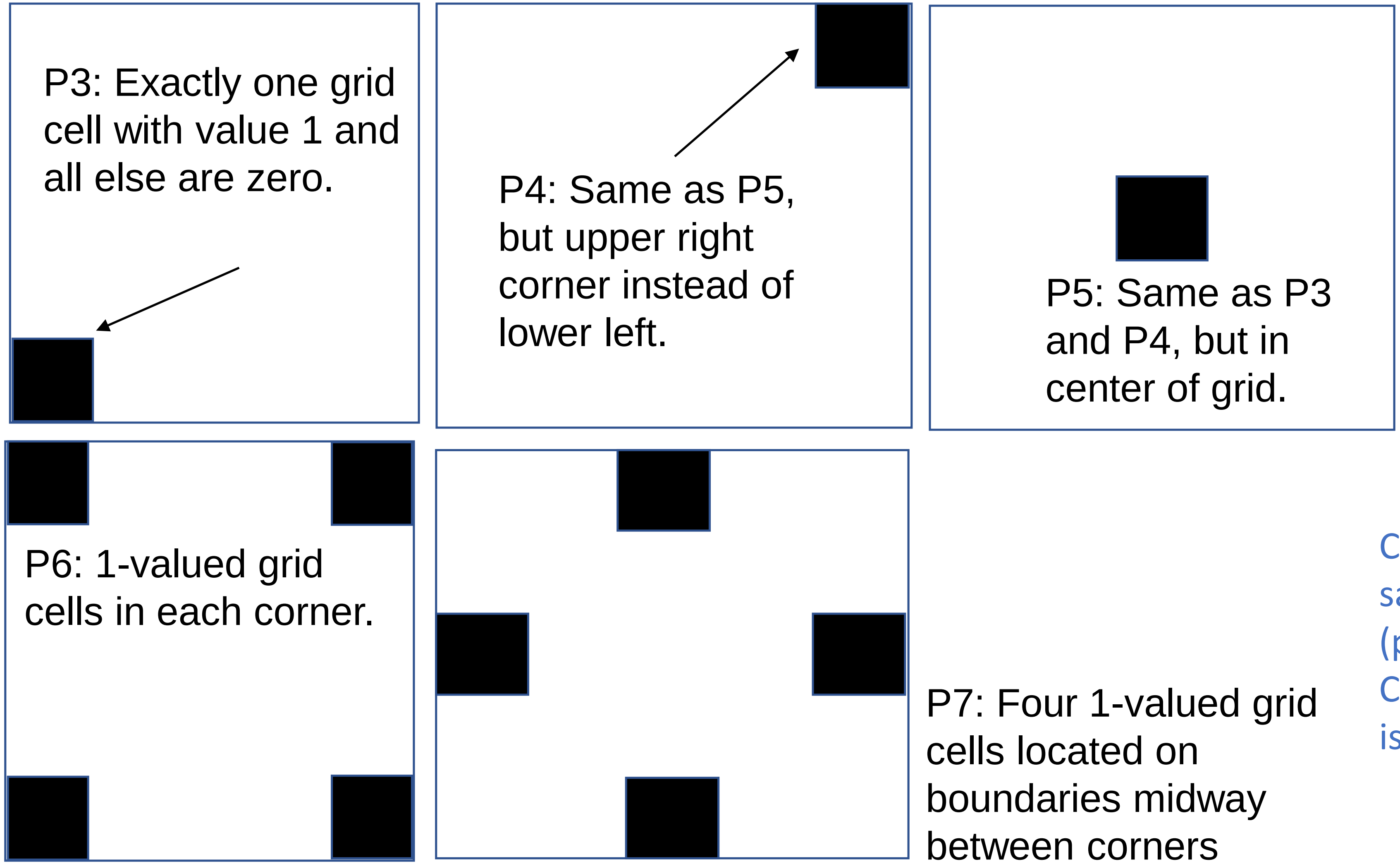
P1: Null Case

P2: Full Case

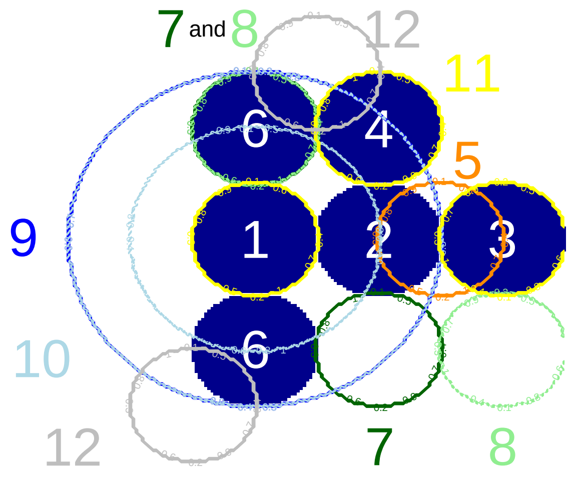
New Geometric Test Cases

Pathological Cases

Going from no to one or a few event points.



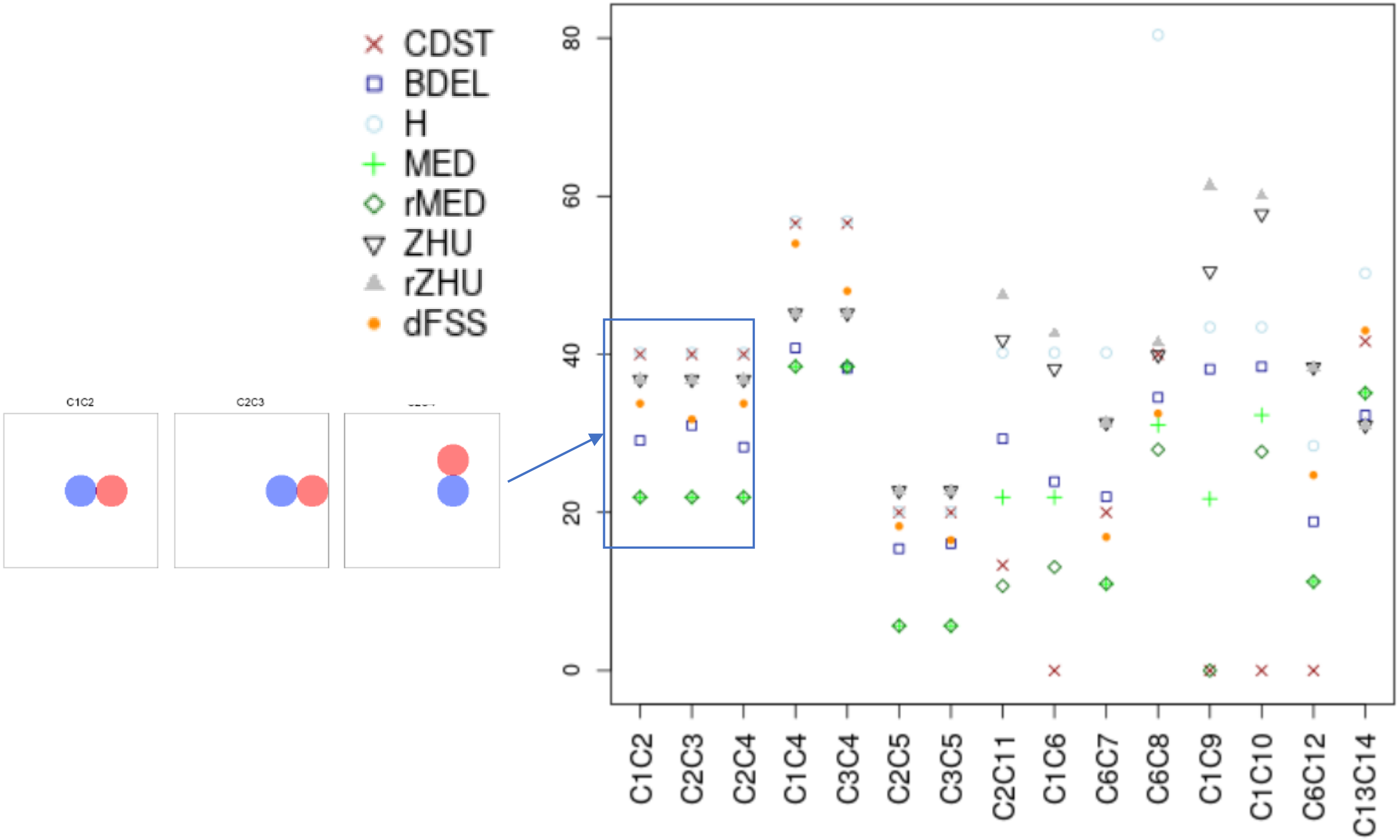
Centroid for P6 and P7 is the same, so CDST(P6, P7) = 0 (perfect score!), but CDST(P3, P6) = CDST(P3, P7) is large.



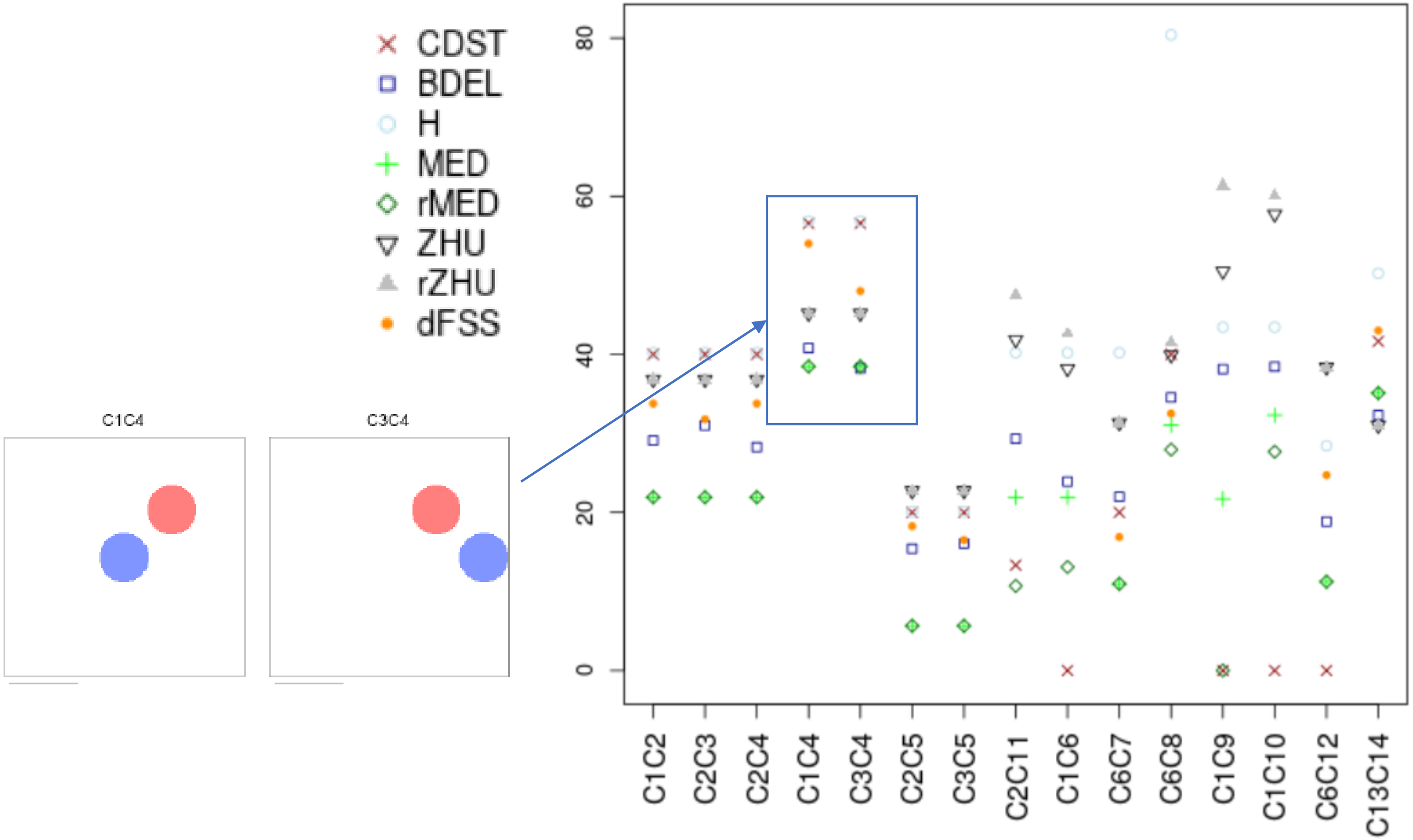
New Geometric Test Cases

Circle Cases

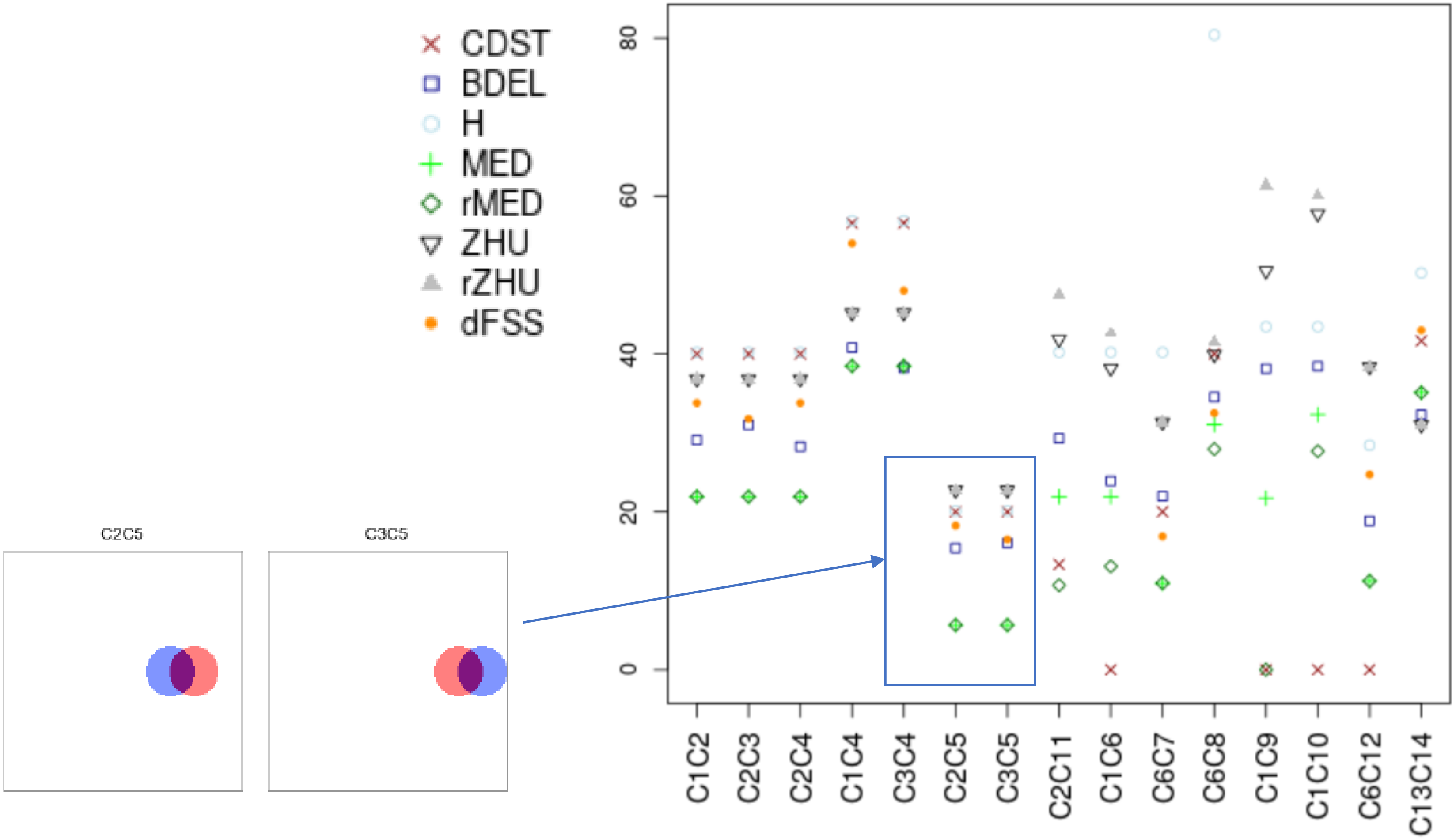
Circle Cases



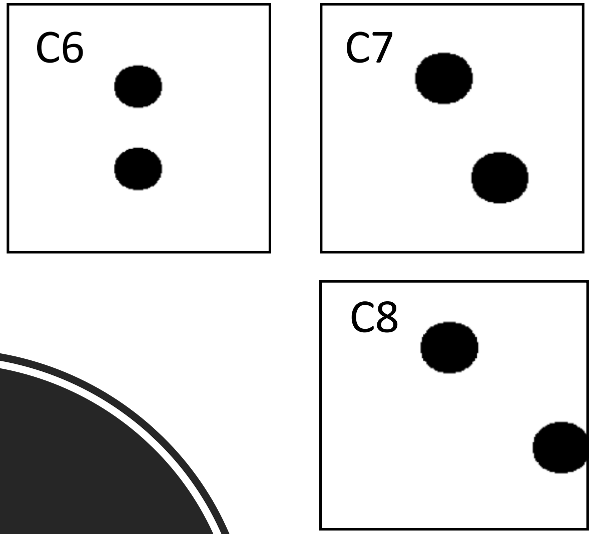
Circle Cases

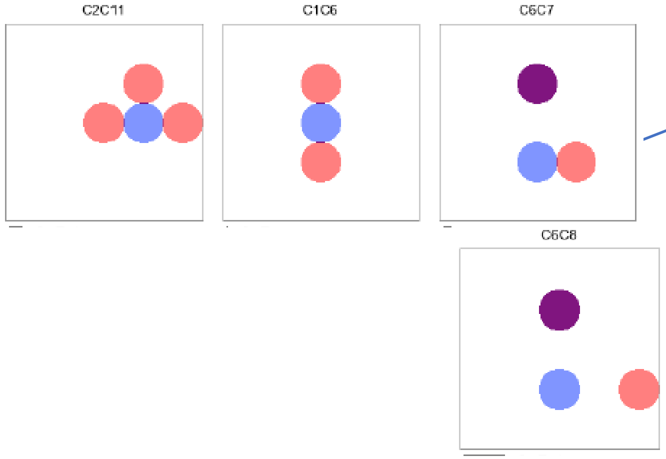


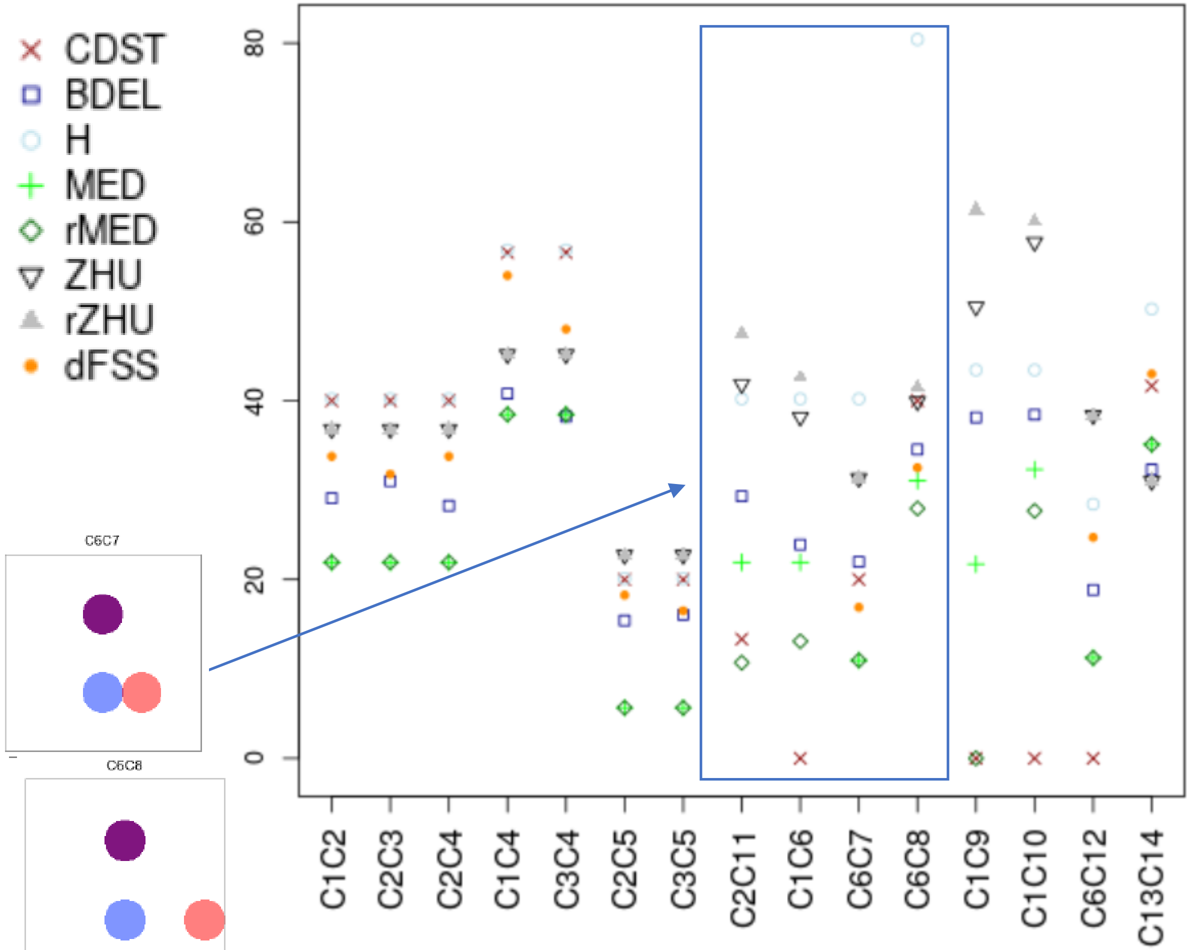
Circle Cases



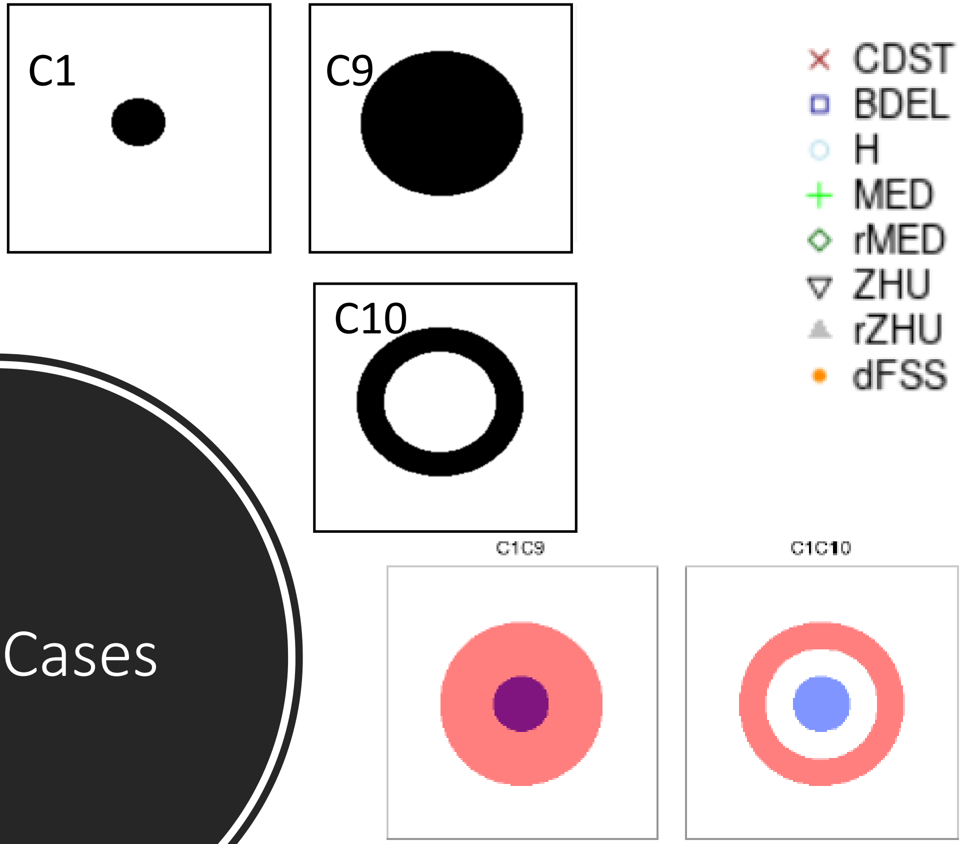
Circle Cases

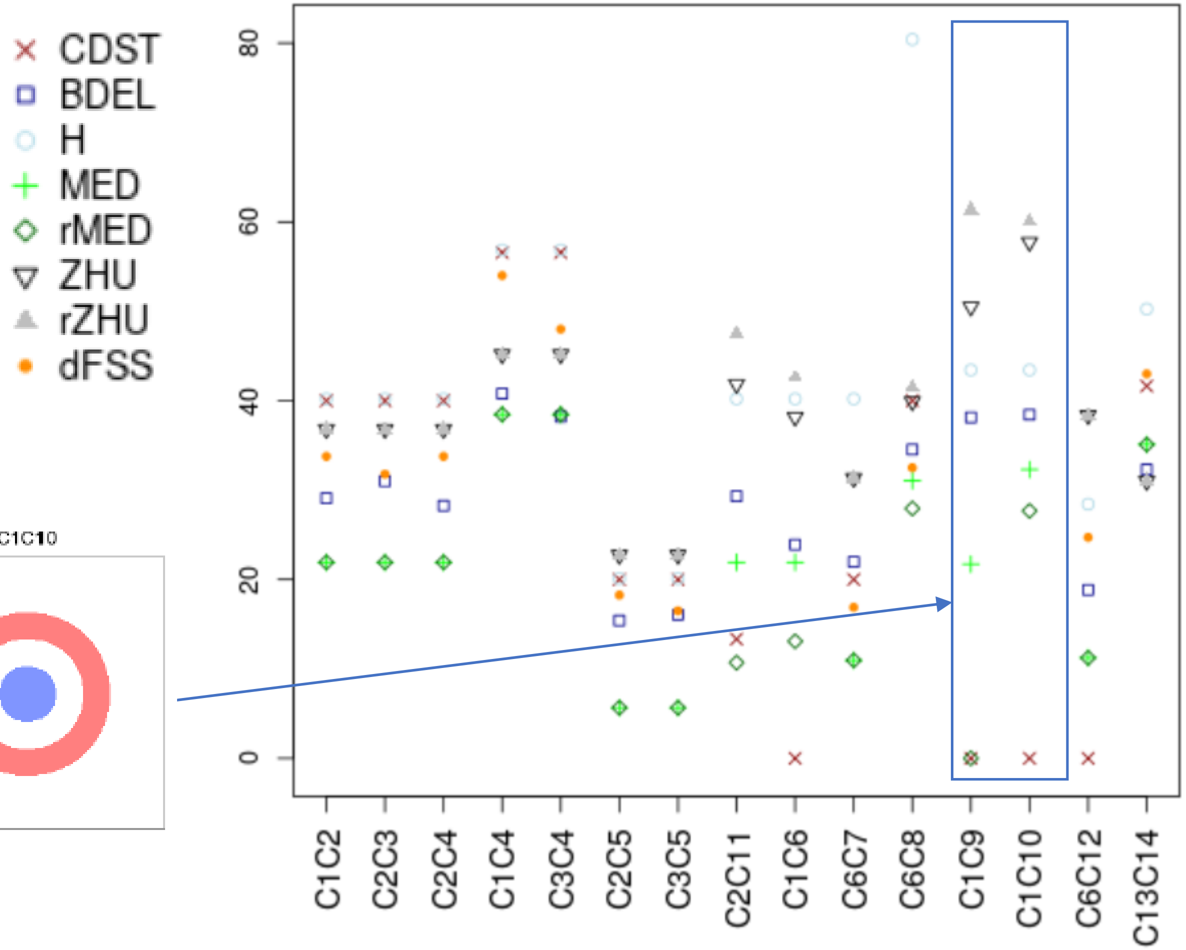




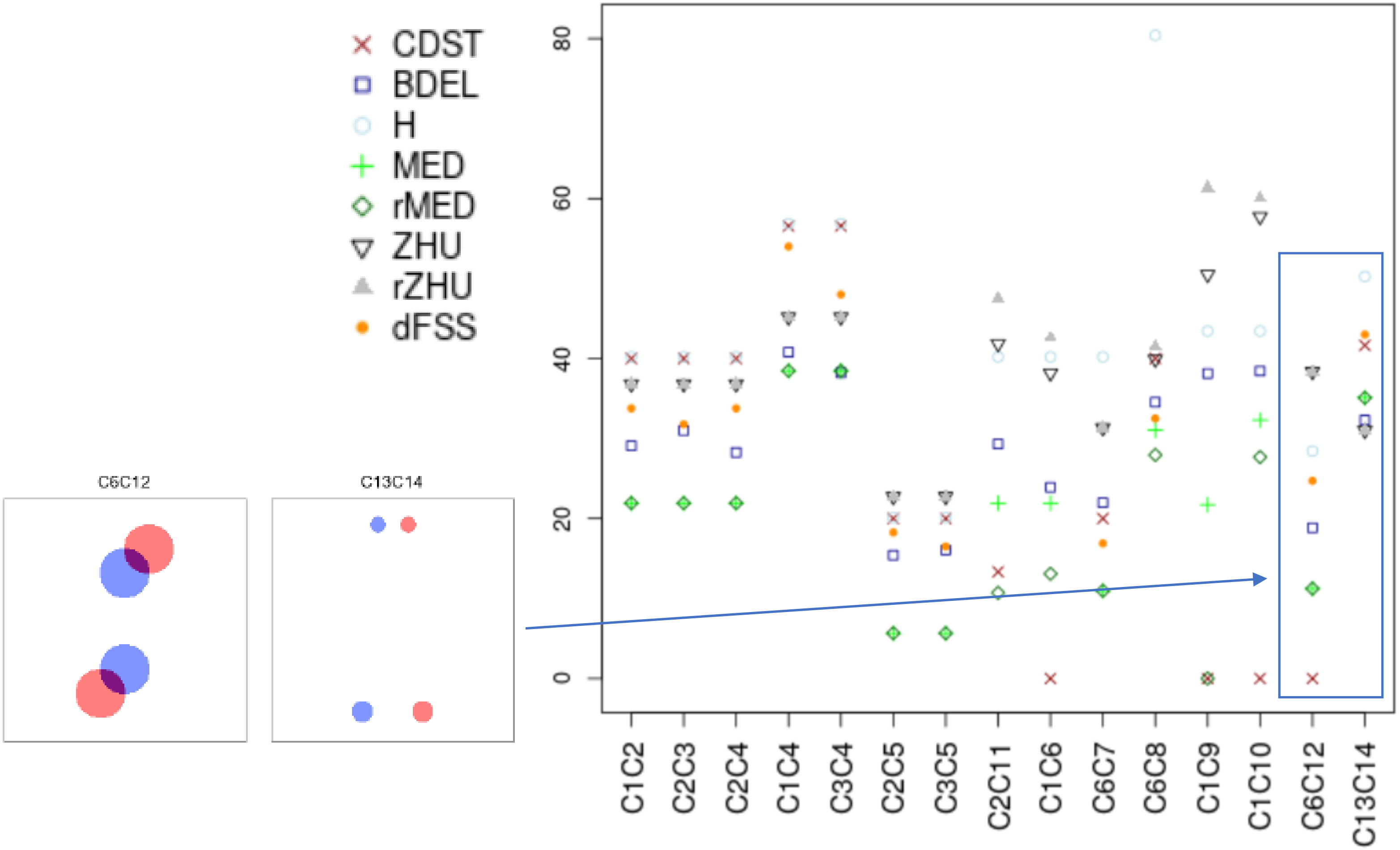


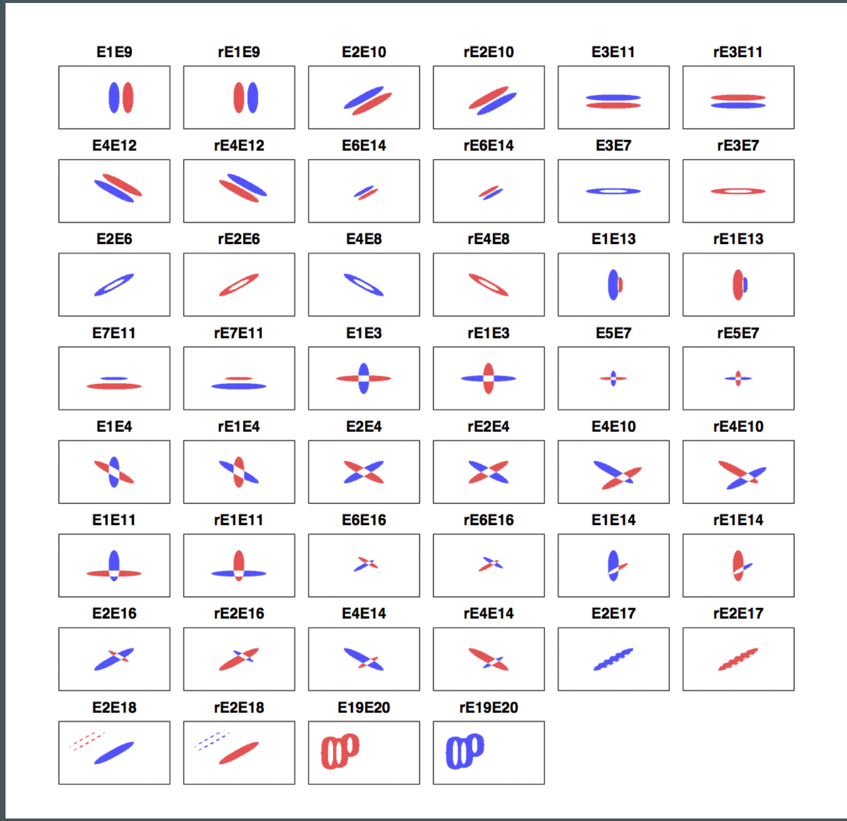
Circle Cases





Circle Cases

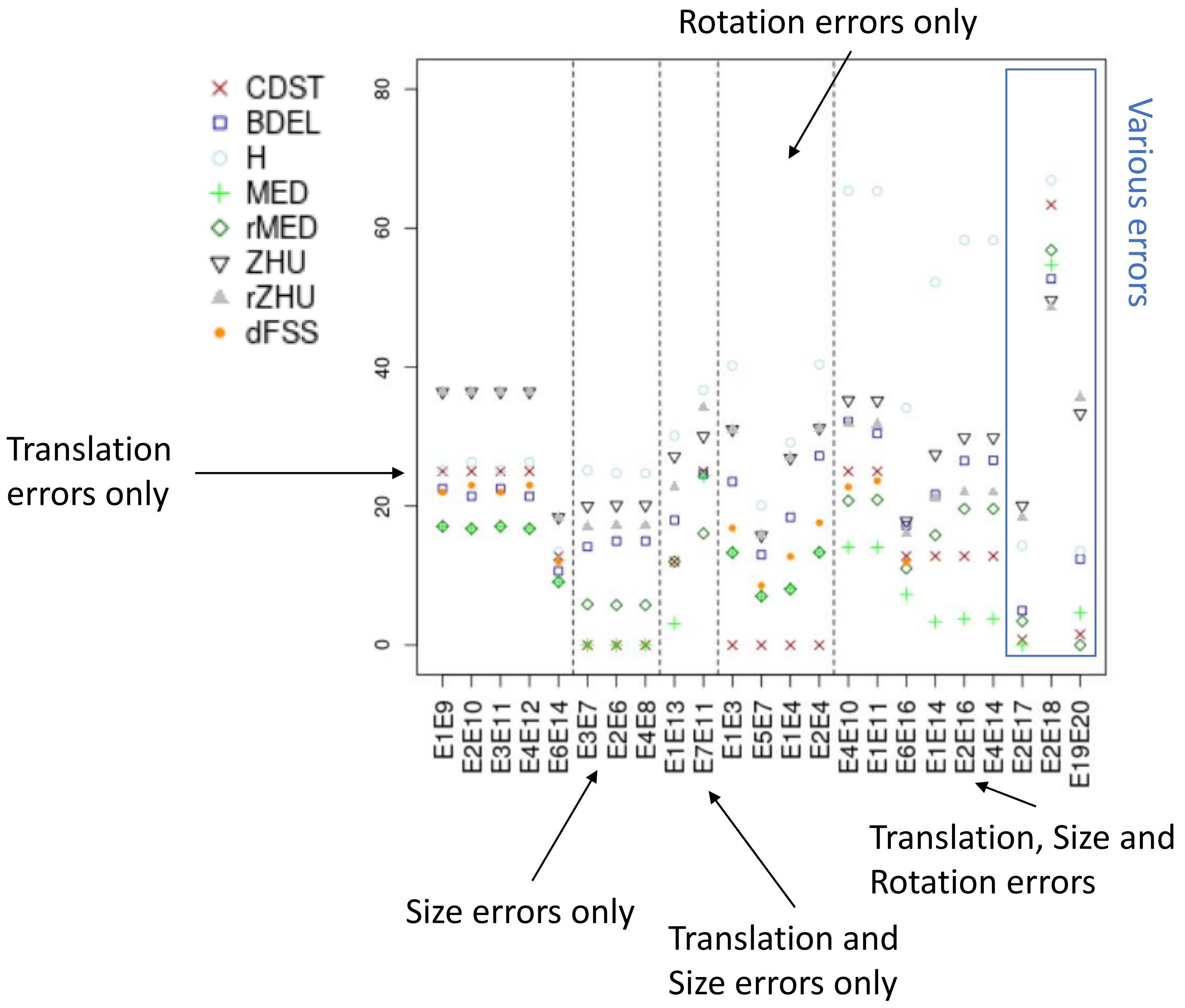




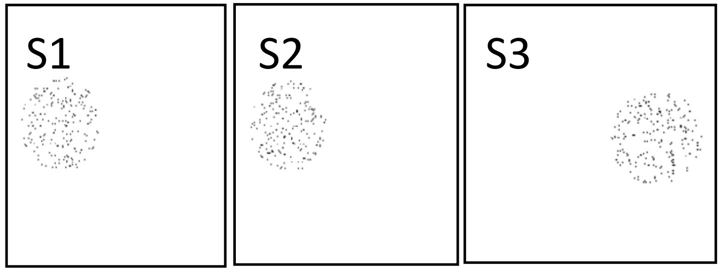
Other cases

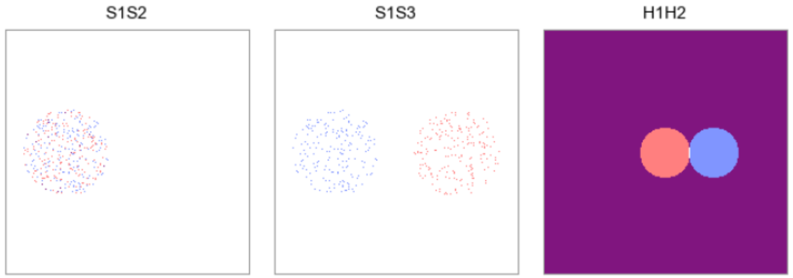
Complex Terrain/Elliptical Cases

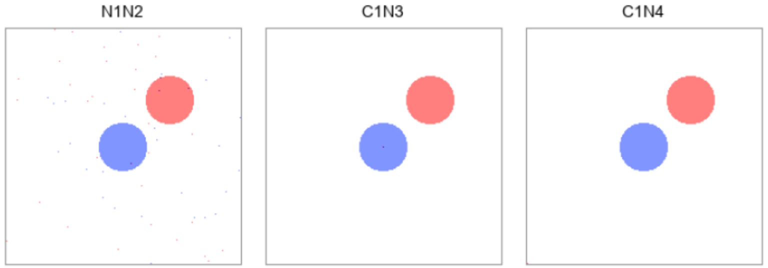
Elliptical Cases



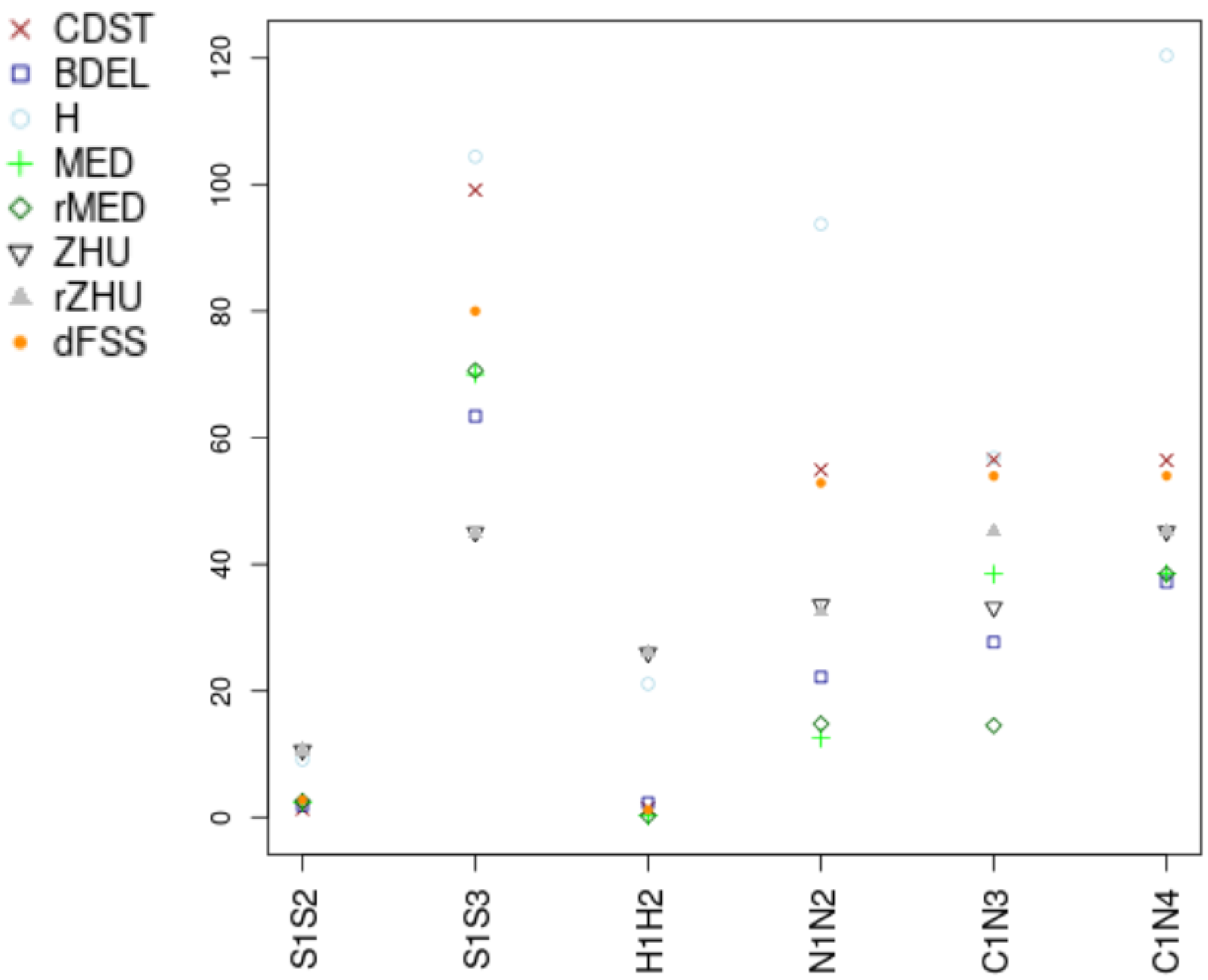
Random Rain, Holes and Noise







Random Rain, Holes, and Noisy Cases



MED, FoM, Z

Modifications to these measures that are metrics

- avg MED(A, B) = $\frac{1}{2}\left(\mathrm{MED}(A, B) + \mathrm{MED}(B, A)\right)$
- min MED(A, B) = $\min\{\mathrm{MED}(A, B), \mathrm{MED}(B, A)\}$
- max MED(A, B) = $\max\{\mathrm{MED}(A, B), \mathrm{MED}(B, A)\}$

Summary

- All cases available (in R format) at MesoVICT web page (https://ral.ucar.edu/projects/icp/)
- Paper in review at MWR (Temporarily Available at https://ral.ucar.edu/staff/ericg/GillelandEtAl2019revision1.pdf)

- Distance-based measures generally give similar information
  - Each has its caveats
- None handle pathological (but very common) situations very well
  - Keep track of the numbers of events in each field for later analysis of results
  - Consider what the best way to handle such cases is for specific purposes

Thank you!

Eric Gilleland

Research Applications Laboratory

National Center for Atmospheric Research

https://ral.ucar.edu/staff/ericg/