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# Visualising verification results when no true reference is available

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**Research & Development**



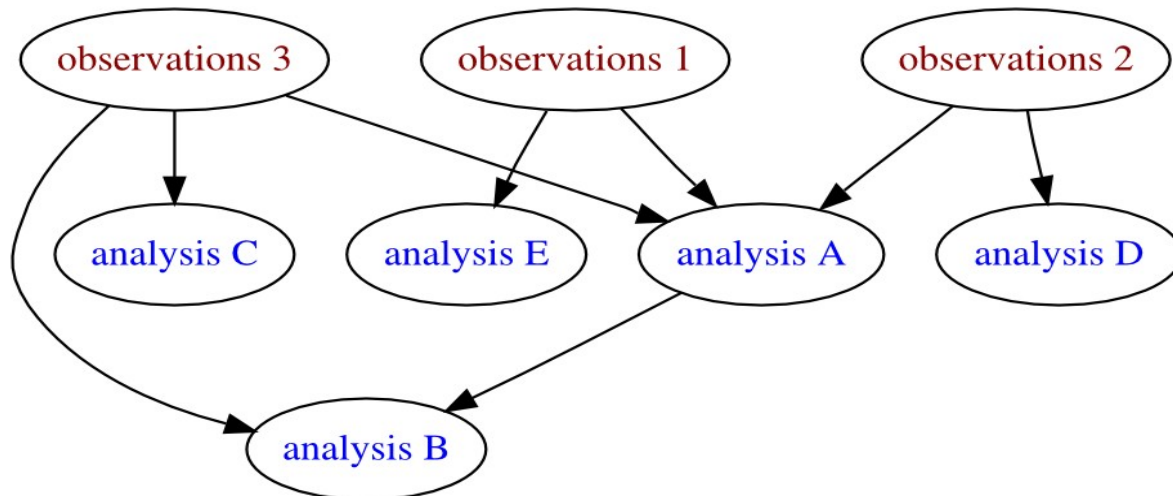
# Contents

- **Problem**
- **A possible solution with**
  - a matrix of verification results
  - multidimensional scaling
- **Case study**
- **Open problems**
- **Conclusions**



# The problem

- In verification, one or more data sets (usually *forecasts*) are compared with one data set (usually *observations*) that is deemed to be *true* or at least *approximately true*.
- But sometimes no such independent truth is available!





# One way to proceed

- **one by one, each data set is defined to be the truth**
- **other data sets are compared with it (using some verification measure).**



# One way to proceed

HIRLAM	ECMWF	LSA	SAF	MODIS	IMS
0.51	0.72	0.27	0.85	1.00	IMS



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0.47	1.00	0.20	0.67	0.72	ECMWF





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	0.47	1.00	0.20	0.67	0.72	ECMWF
	1.00	0.47	0.16	0.52	0.51	HIRLAM



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0.47	1.00	0.20	0.67	0.72	ECMWF
1.00	0.47	0.16	0.52	0.51	HIRLAM

- **The matrix is symmetric (because of the measure used!) and we need only one half of it...**



# Result

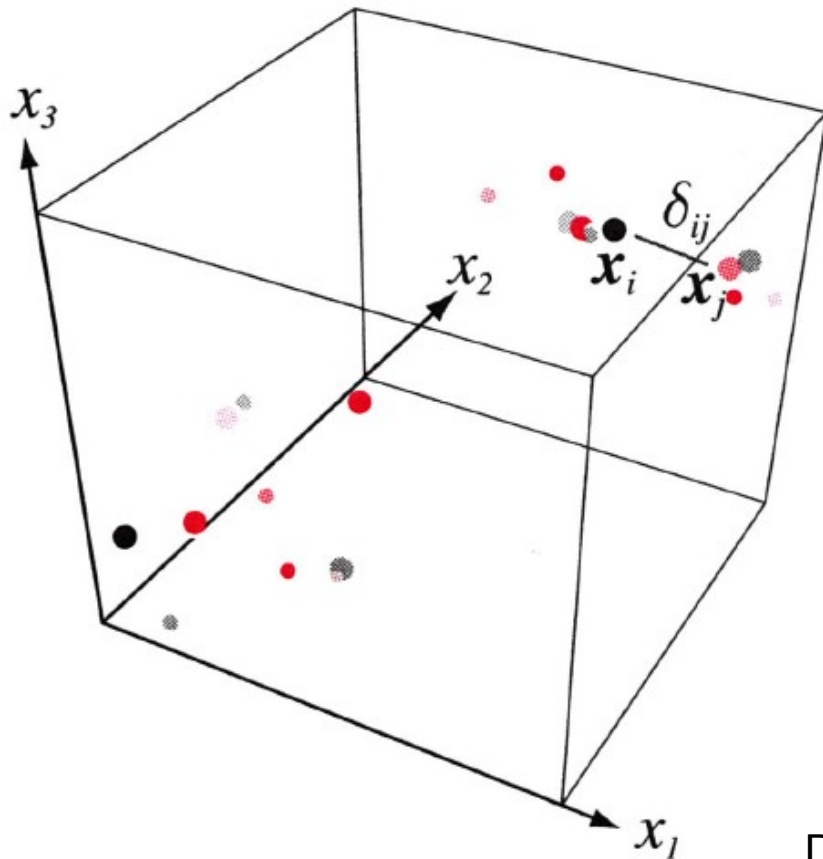
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				HIRLAM

- **This matrix includes all information from the comparisons, but can be cumbersome to interpret.**
  - but there is a way to visualize this...

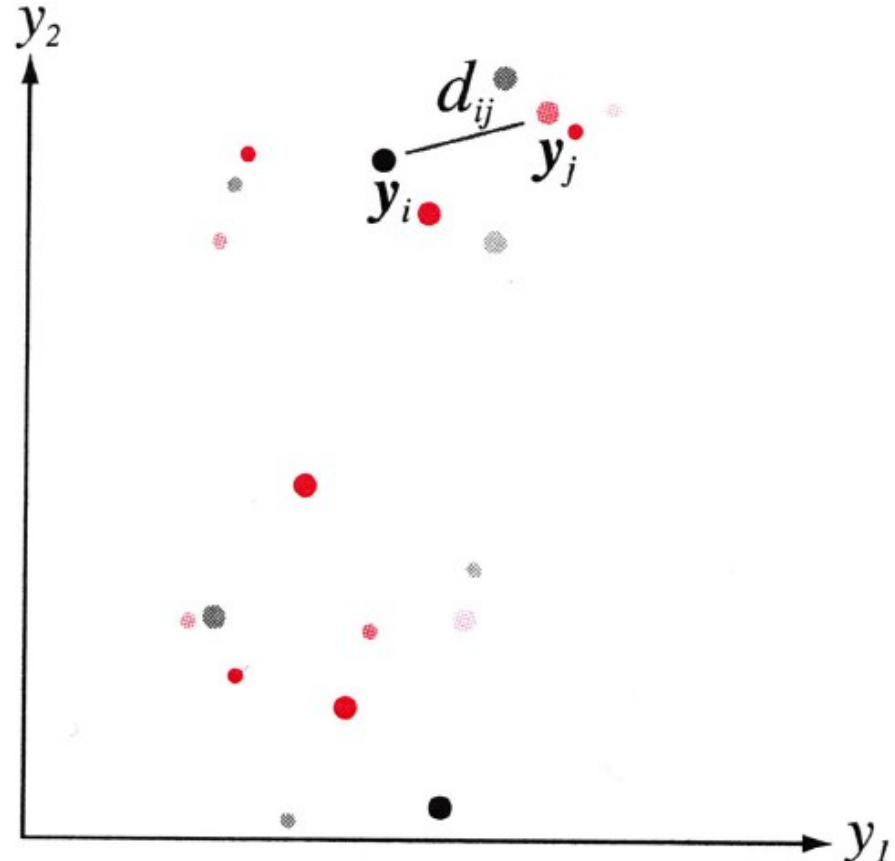


# Multidimensional Scaling (MDS)?

*source space*



*target space*





# Multidimensional Scaling (MDS)

- **simple MDS with Euclidean distance (*Principal Coordinate Analysis*) is equal to *Principal Component Analysis* where only the first two components are plotted**
- **better results can be achieved using iterative methods (e.g., *Kruskal's non-metric MDS*, *Sammon mapping*)**
  - minimize some cost function

Kruskal:

$$\frac{\sum_{i < j} (d_{ij} - \delta_{ij})^2}{\sum_{i < j} \delta_{ij}^2}$$

Sammon:

$$\sum_{i < j} \frac{(d_{ij} - \delta_{ij})^2}{\delta_{ij}}$$



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# How does MDS help us?

- **To calculate MDS we need *distances* between data points, not the *actual coordinates***
- **Can we use our verification matrix as a distance matrix? Yes!**
  - But don't talk about distances but the dissimilarities...



# Dissimilarities vs. distances

- **dissimilarities have to satisfy**
  - $d(i,j) \geq 0$
  - $d(i,i) = 0$
  - $d(i,j) = d(j,i)$  (sometimes not even this!)
- **but not necessary (which genuine distances have to satisfy)**
  - $d(i,j) \leq d(i,h) + d(h,j)$





# Some verification measures as dissimilarities

- **(we use only verification measures for categorical variables)**
- **Measures known as dissimilarities in literature**
  - Proportion Correct (the simple matching coefficient)
  - Critical Success Index (the Jaccard coefficient)
- **Possible measures as dissimilarities**
  - some Skill Scores (Heidke SS used in this study)
- **Actually, we use 1-HSS, 1-PC, 1-CSI, etc.**



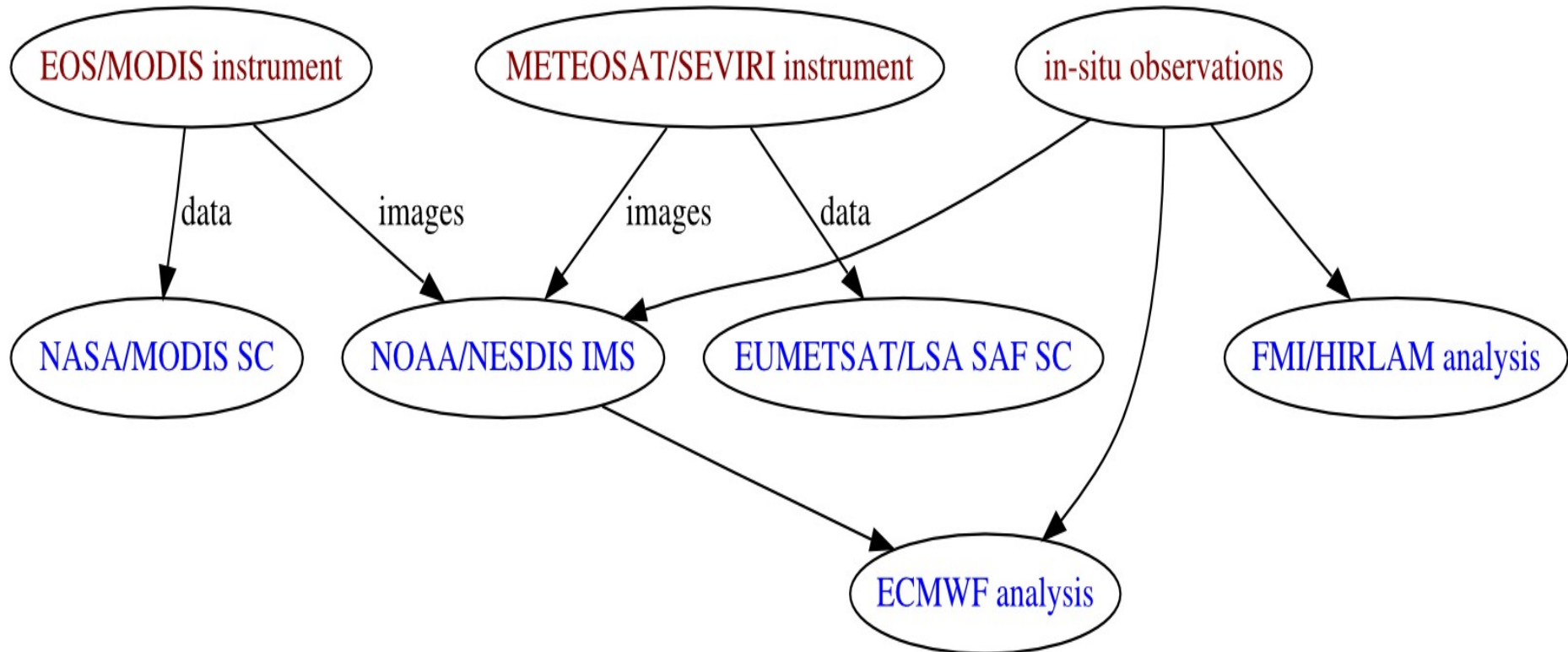
# Our plan

- 1. calculate some verification measures**
- 2. compose a matrix of measures**
- 3. calculate the Sammon mapping**
- 4. show the matrix and the Sammon mapping**



# Case study of different snow analyses

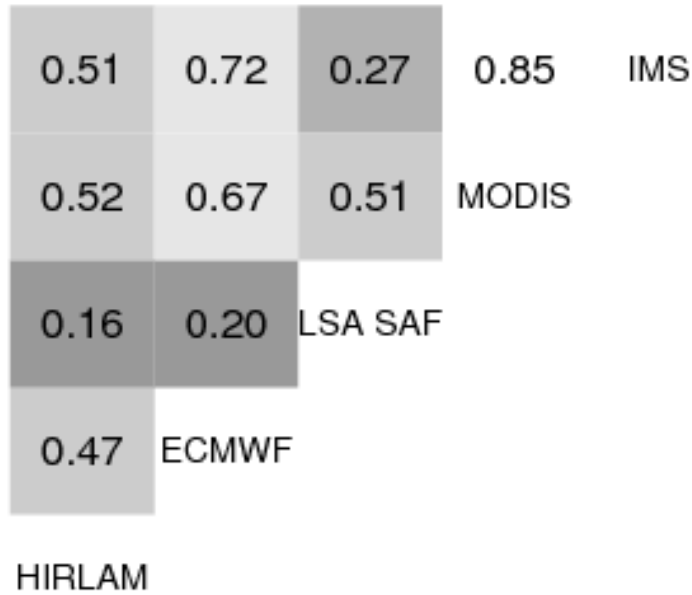
- **no independent ground truth!**



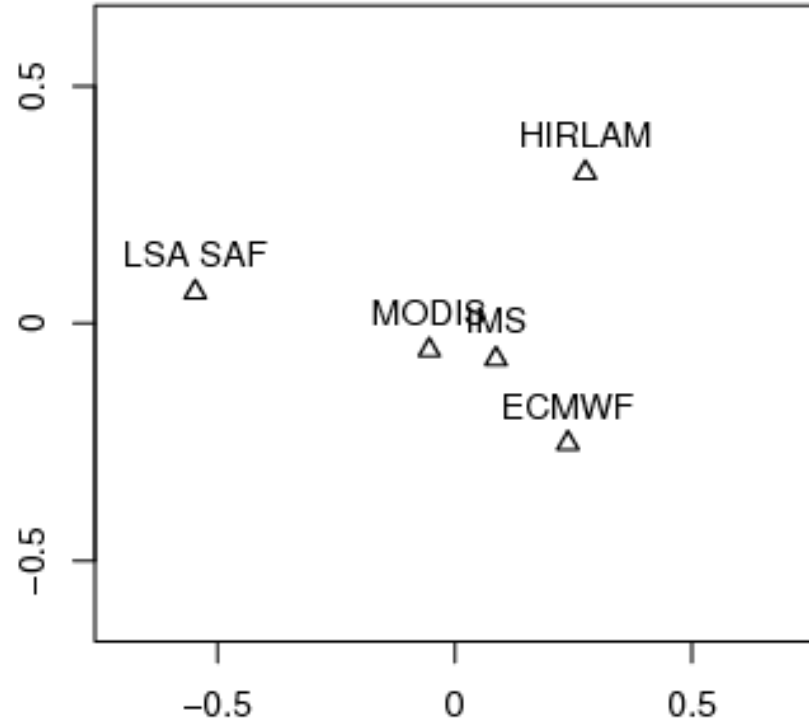
- **data from January to June 2006, Northern Europe**



(a) HSS  $h < 600$  Cluster # 1



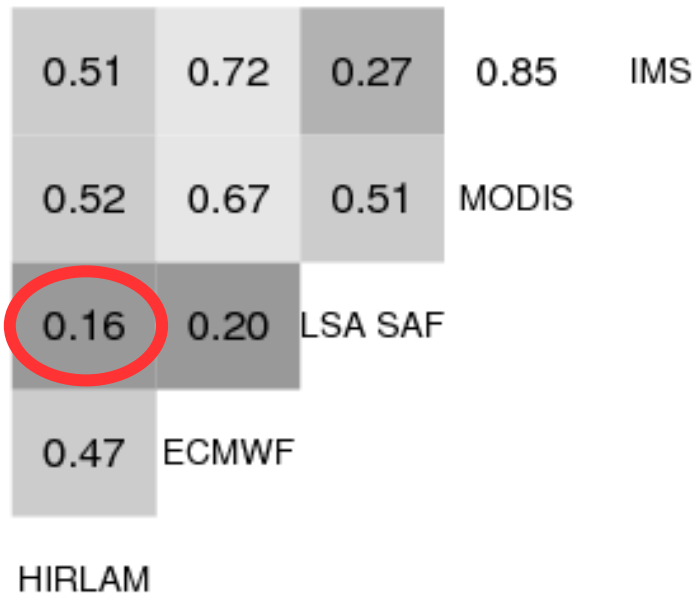
Sammon mapping



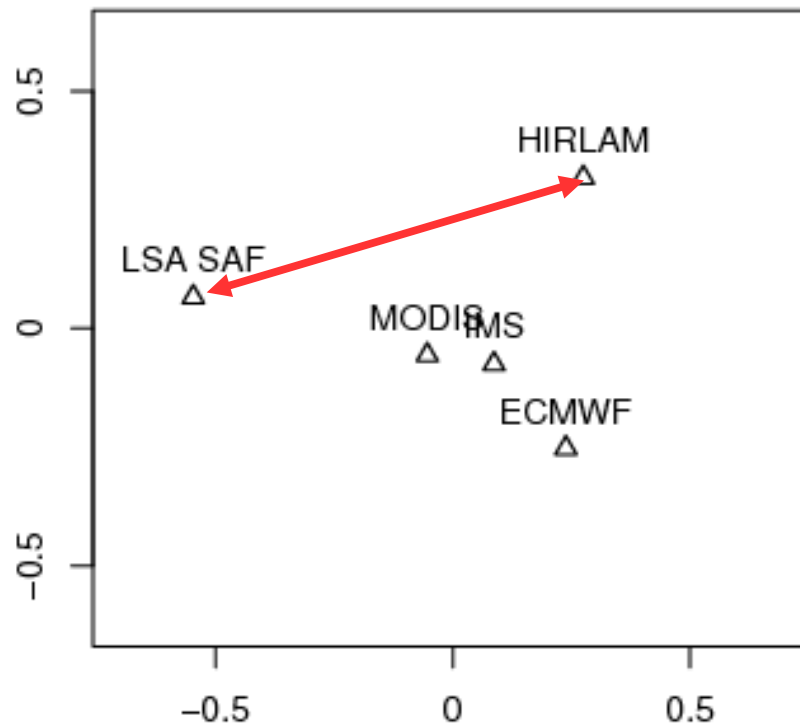


# Small HSS, large distance

(a) HSS  $h < 600$  Cluster # 1



Sammon mapping



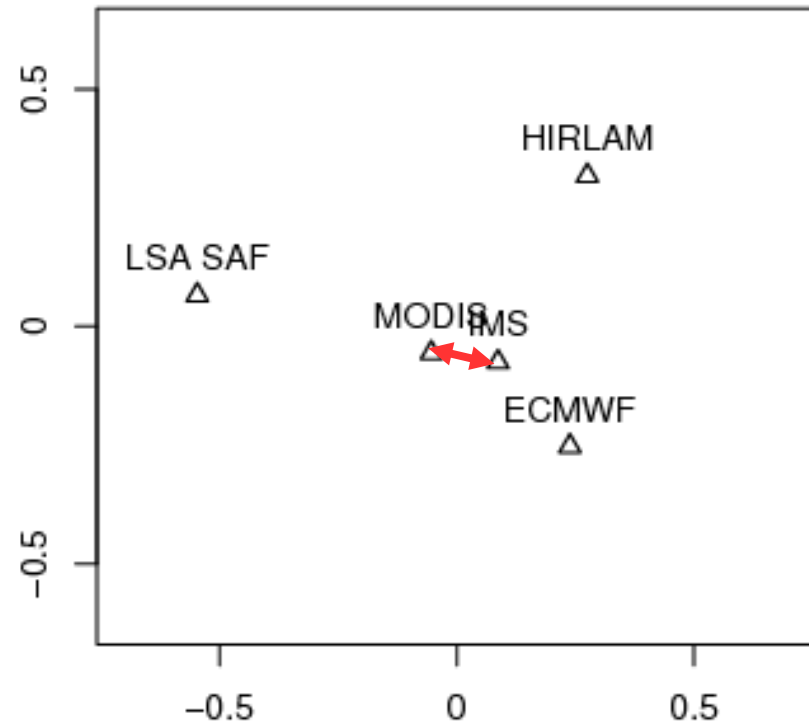


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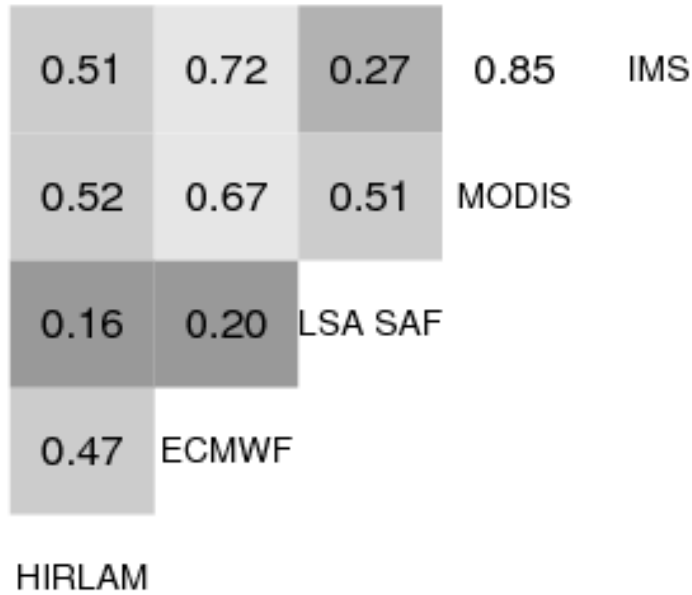
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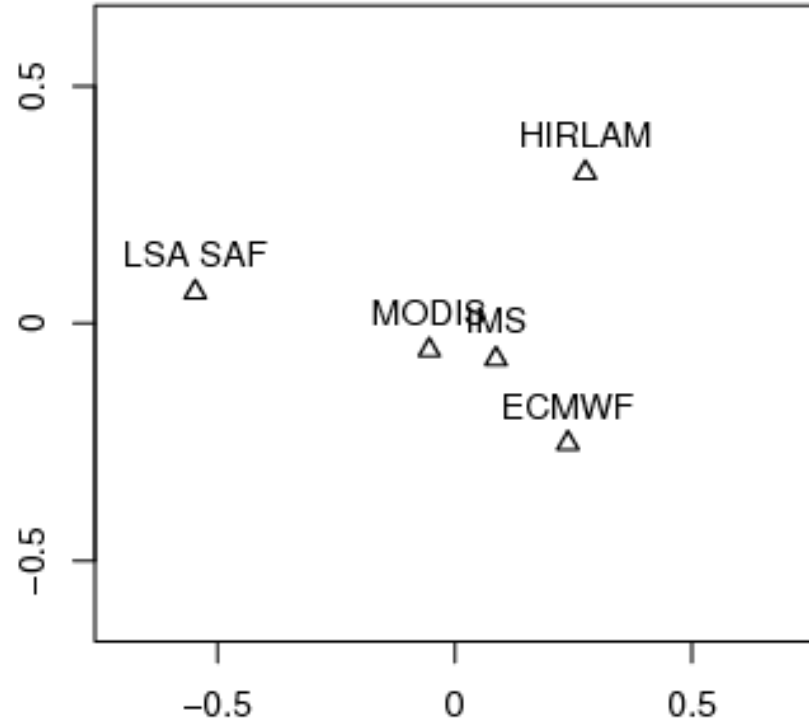




(a) HSS  $h < 600$  Cluster # 1



Sammon mapping





# Open questions

- **how to assess the uncertainty in mapping (e.g., how to construct the confidence intervals)**
  - hard to do with Sammon mapping
- **how new data points can be added**
  - hard to do with Sammon mapping
- **what other verification measures are meaningful as dissimilarities**





# Conclusions

- **a simple method for visualizing a comparison of different data sets, when none of them is the *truth***
- **... is still not perfect, and can be improved...**



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# References

- **More about our work in**
  - Hyvärinen et. al. (2009) *Comparison of snow cover from satellite and numerical weather prediction models in Northern Hemisphere and northern Europe*. Journal of Applied Meteorology and Climatology, DOI: 10.1175/2008JAMC2069.1
- **More about MDL in**
  - Ripley (1996) *Pattern Recognition and Neural Networks*
  - Duda et. al. (2001) *Pattern Classification. Second edition*
  - Venables and Ripley (2002) *Modern Applied Statistics with S. Fourth Edition*
- **More about dissimilarities in**
  - Kaufman & Rousseeuw (1990) *Finding Groups in Data*