University of Southampton

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

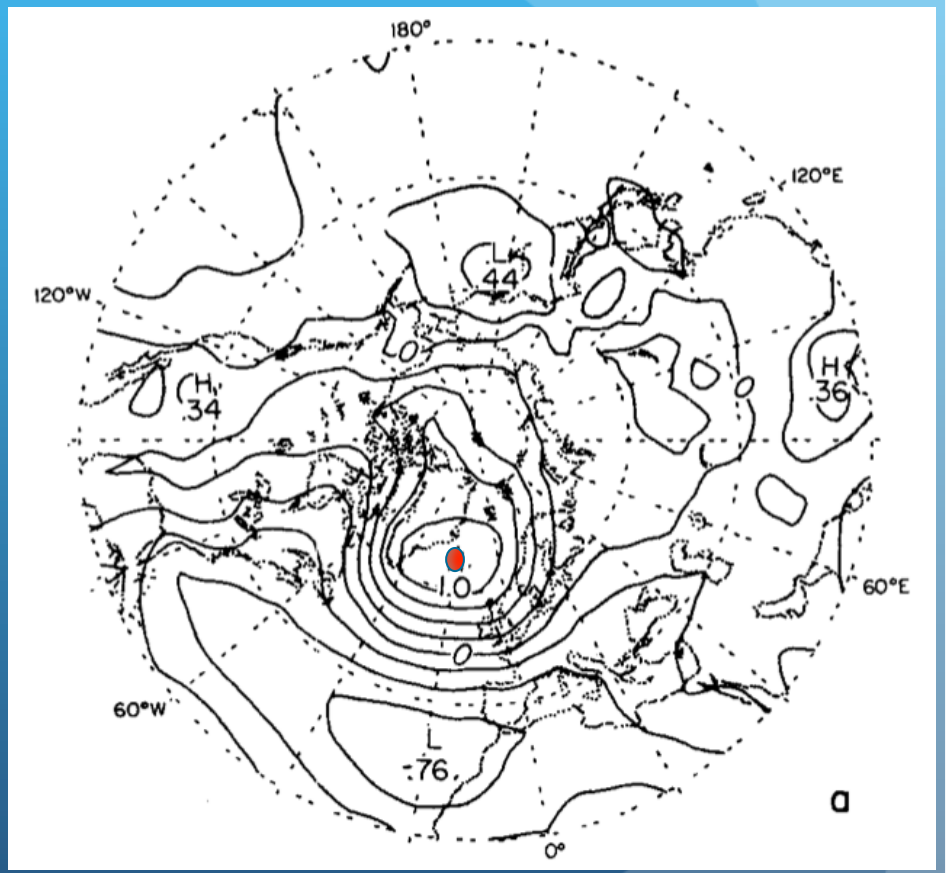
Identifying Teleconnection Patterns from Point Correlation Maps using Self Organizing Maps

Freja Hunt, Joel Hirschi and Bablu Sinha
National Oceanography Center, Southampton, UK

8th April 2011
EGU General Assembly Vienna

Correlation Maps

- Wallace & Gutzler 1981
- Correlate a grid point with every other grid point on the map for all grid points

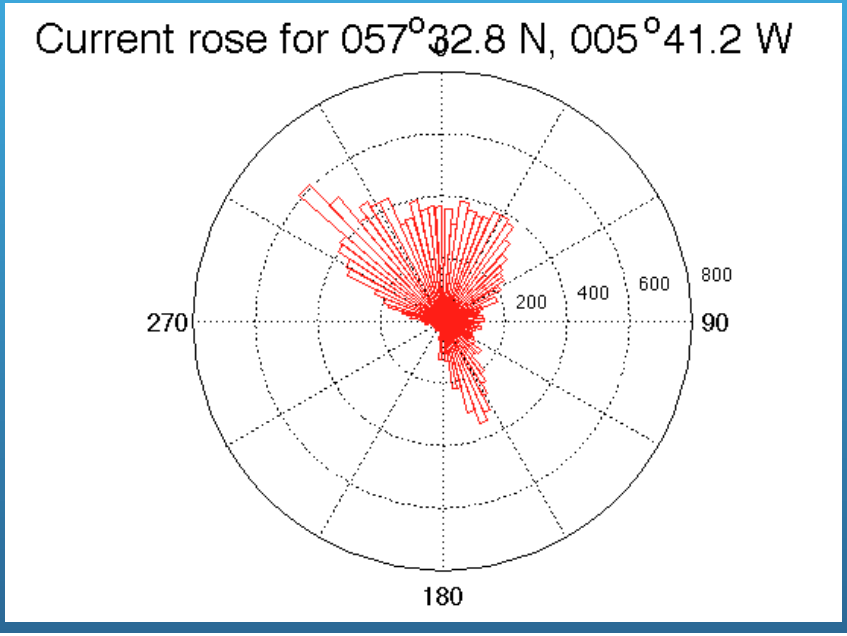


Self Organizing Maps (SOMs)

- What is a SOM?
  - An unsupervised non-linear neural network
  - Finds representative patterns in the data
  - Results are arranged topologically
    - Similar results are close together, different results are far apart
- Examples of SOMs in teleconnections
  - Leloup et al 2008 ENSO, Johnson et al 2008 NAO
- Simple example

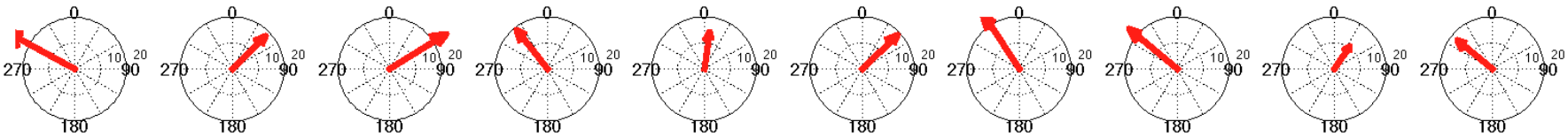
How do Self Organizing Maps work?

- Current data from a moored buoy in Loch Shieldaig, Scotland



Actual data will be shown in RED

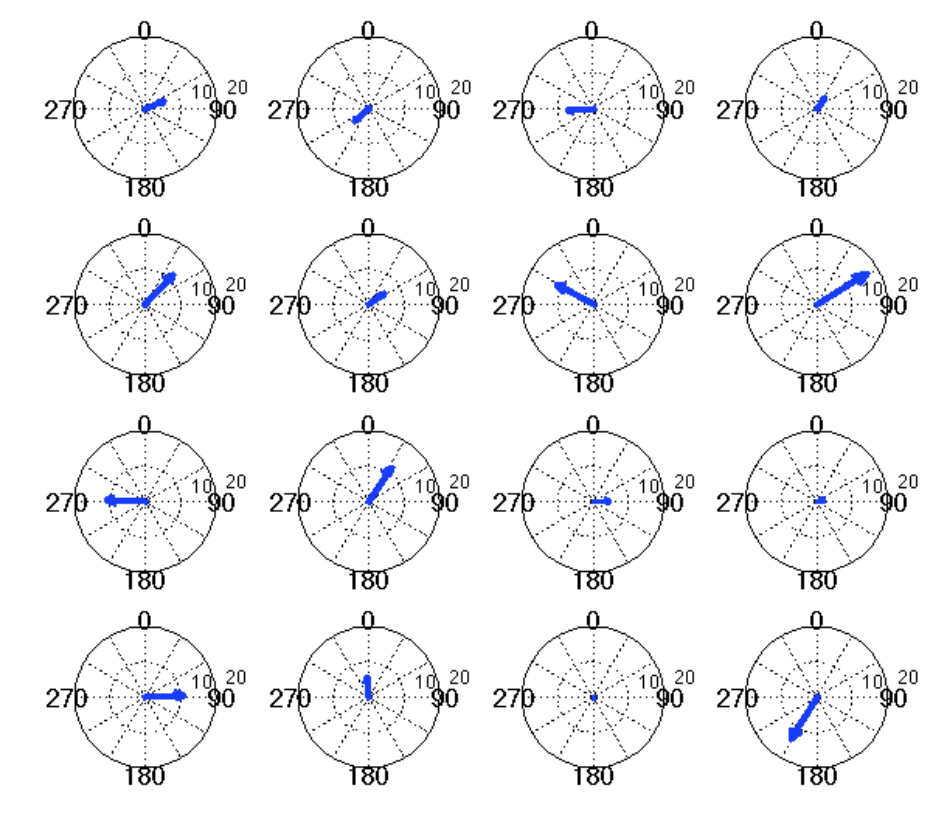
SOM data will be shown in BLUE



Data courtesy of the British Oceanographic Data Centre

How do Self Organizing Maps work?

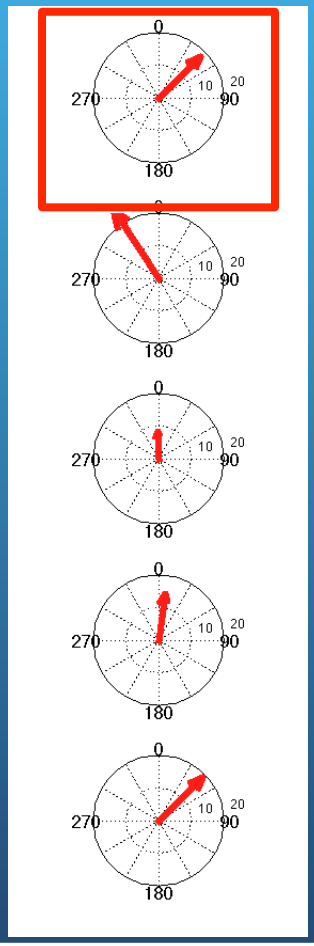
- Initialization
  - How many patterns?
  - Starting patterns

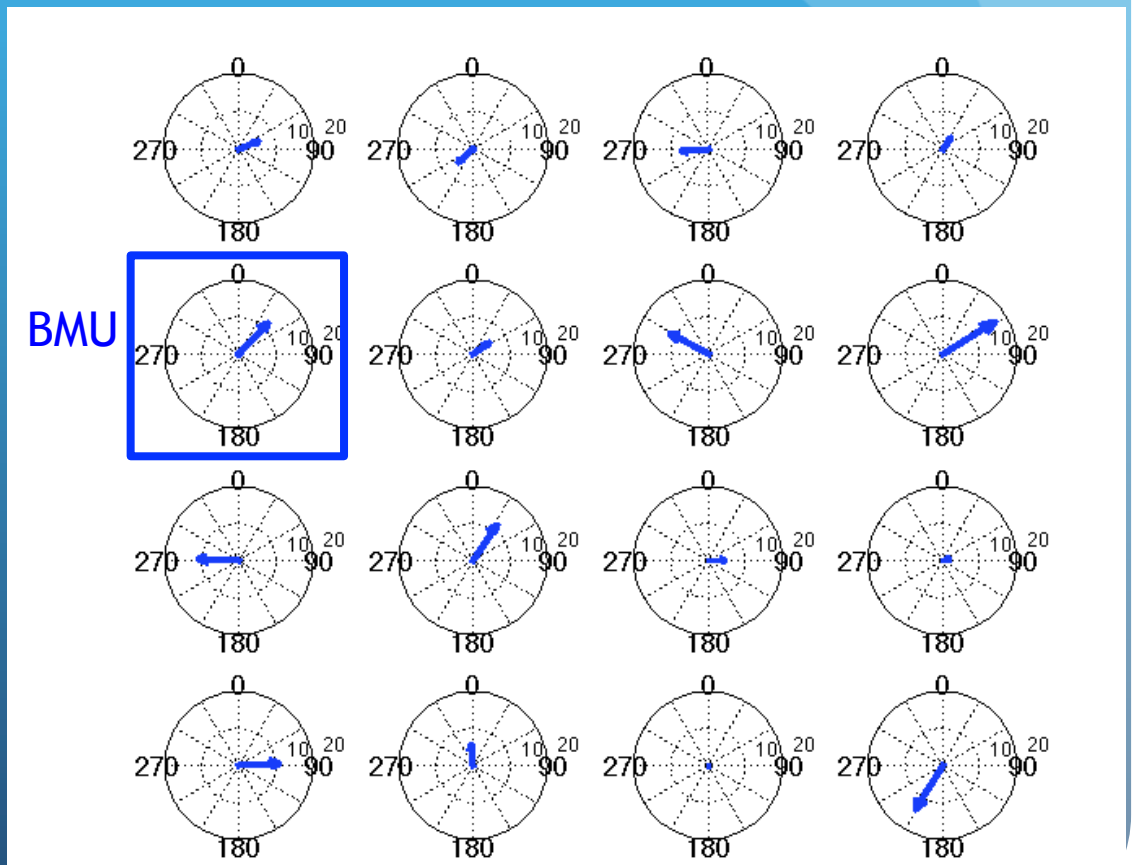


How do SOMs work?

1. Present each data pattern to SOM
2. Locate BMU
3. Update BMU – learning rate
4. Update neighbors - neighborhood function
5. Learning rate and neighborhood function reduce over time

2. Locate SOM pattern most similar to data pattern

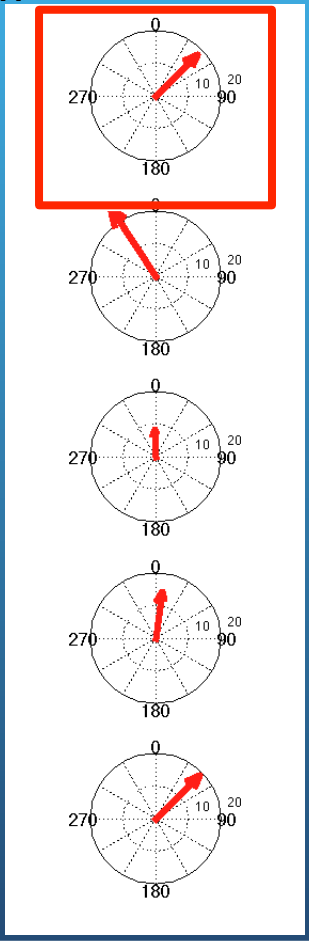


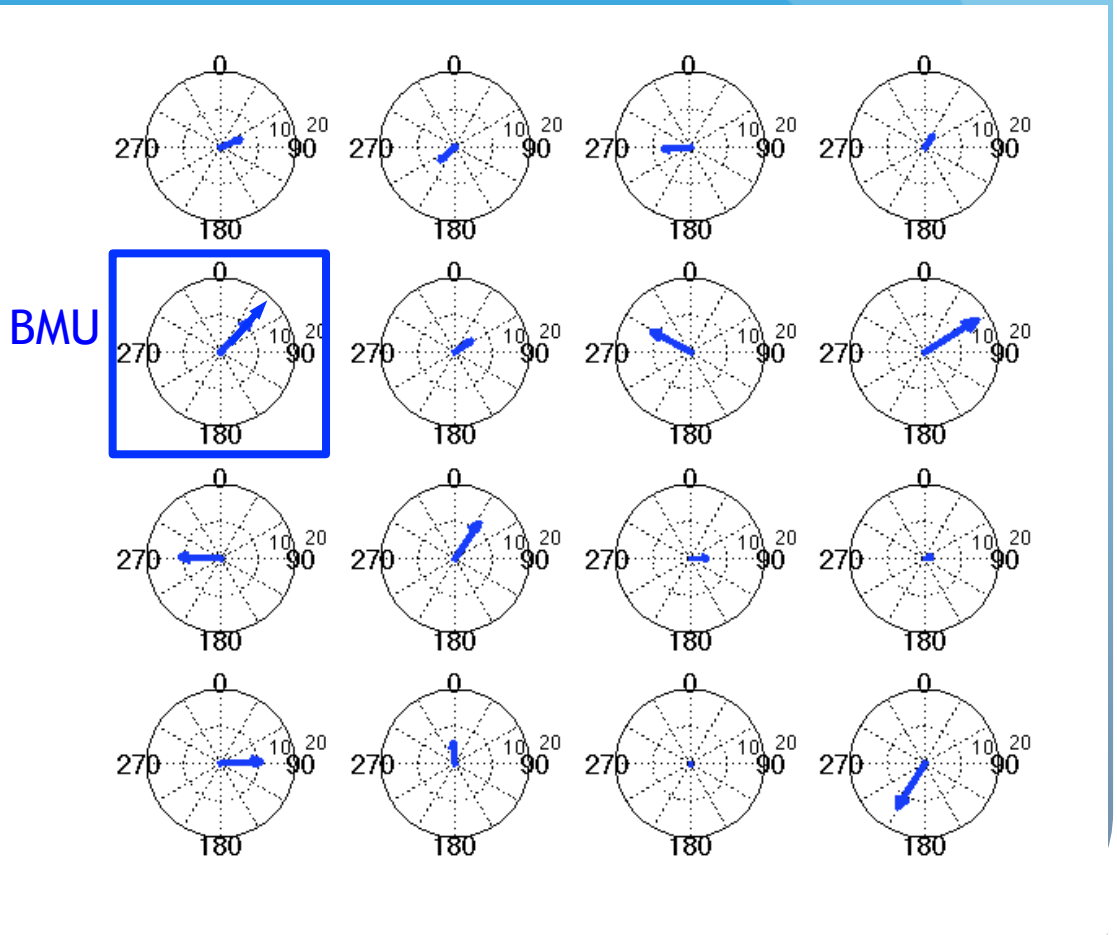


How do SOMs work?

1. Present each data pattern to SOM
2. Locate BMU
3. Update BMU – learning rate
4. Update neighbors - neighborhood function
5. Learning rate and neighborhood function reduce over time

3. Update BMU to more closely resemble the data pattern

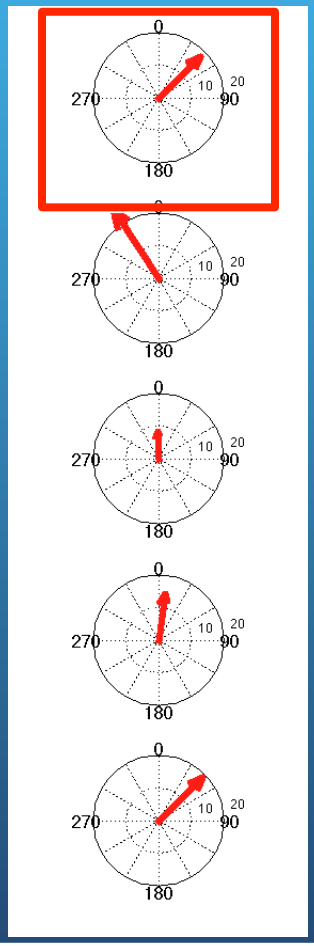


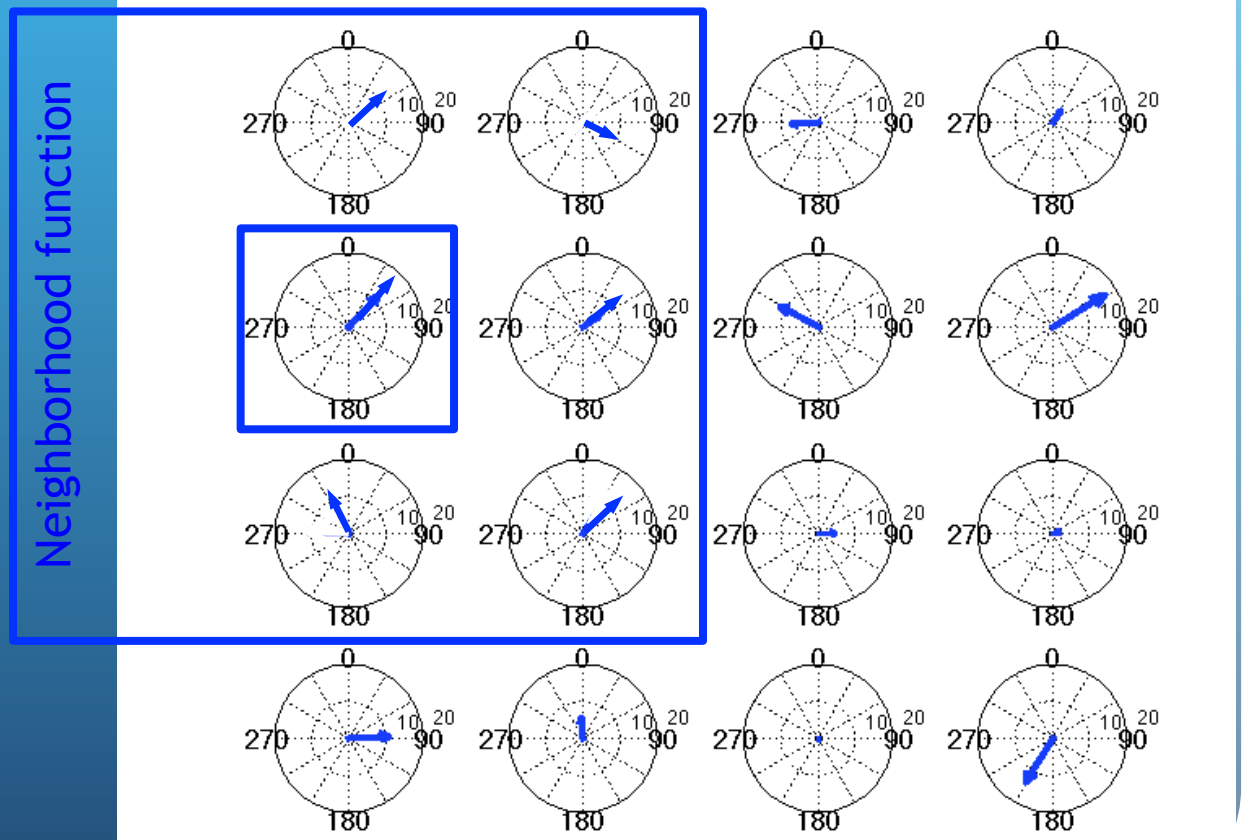


How do SOMs work?

1. Present each data pattern to SOM
2. Locate BMU
3. Update BMU – learning rate
4. Update neighbors - neighborhood function
5. Learning rate and neighborhood function reduce over time

4. Update neighboring SOM patterns

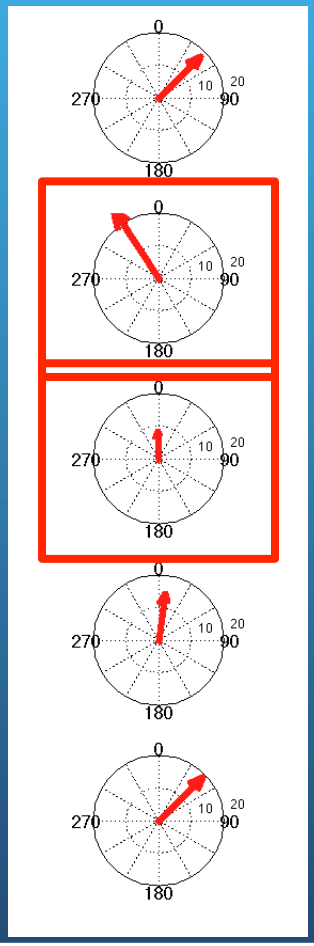


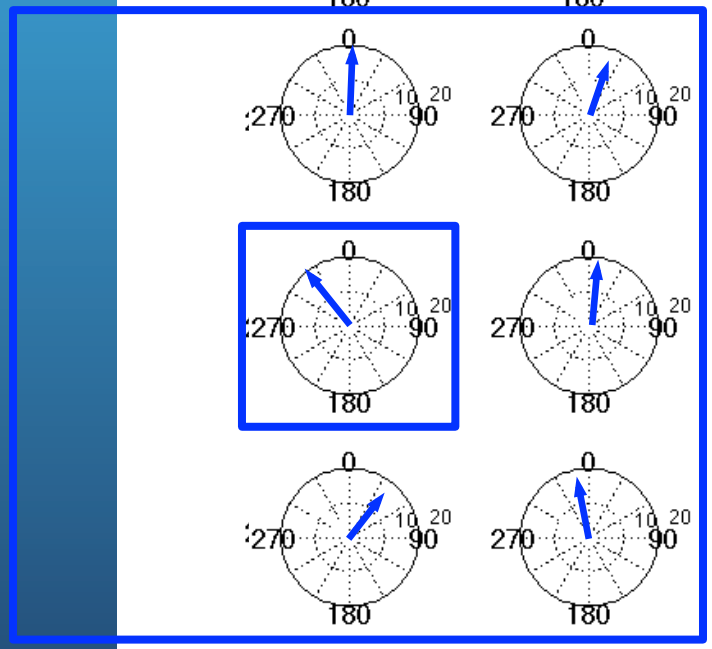


How do SOMs work?

1. Present each data pattern to SOM
2. Locate BMU
3. Update BMU – learning rate
4. Update neighbors - neighborhood function
5. Learning rate and neighborhood function reduce over time

1. Iteratively present each data pattern to SOM



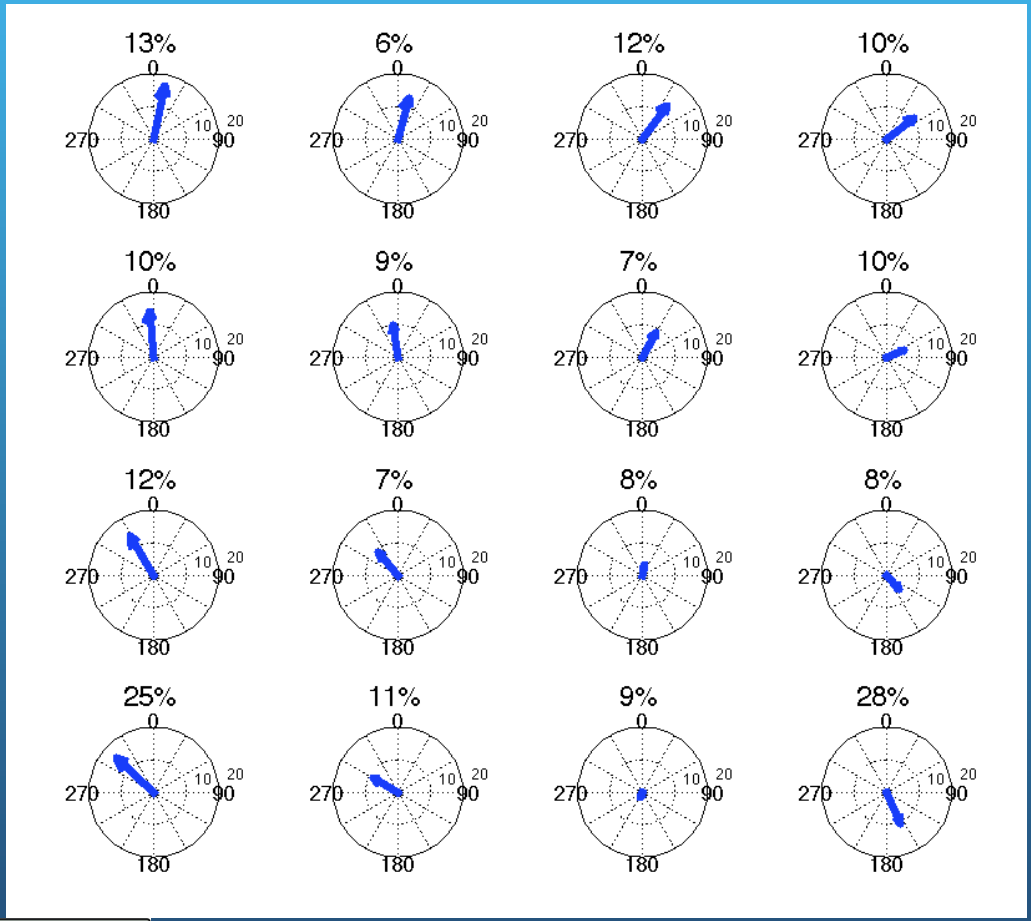


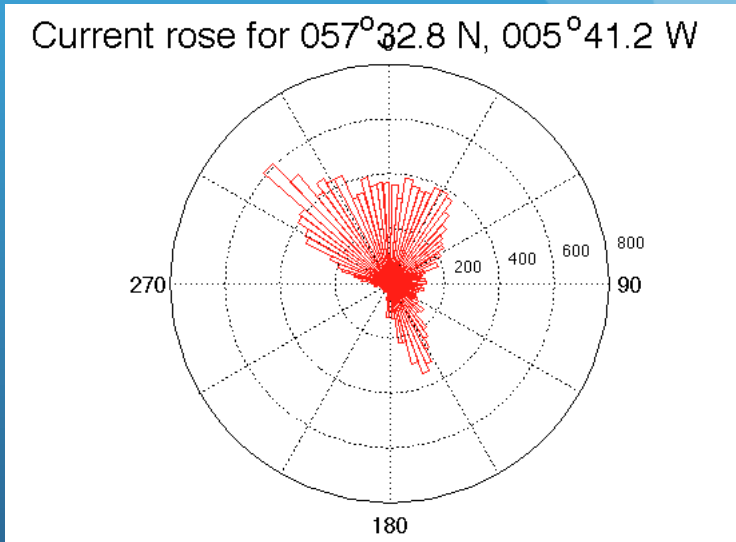
How do Self Organizing Maps work?

- Comparison
  - Compare original data patterns with SOM patterns
  - For each data pattern find its BMU
  - Add up number of times each SOM pattern is BMU to get ‘hits’
    - Frequency of occurrence

How do Self Organizing Maps work?

Percentage frequency occurrence of each SOM pattern in the original data

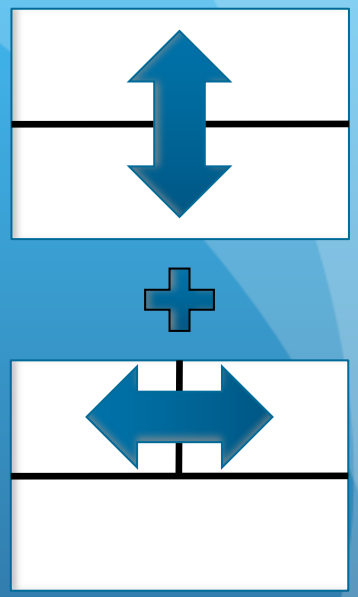




Correlation Map SOMs

- Gridded data set
- Point correlation maps for each grid point
- nx by ny correlation maps
- Present correlation maps to SOM rather than raw data
- Advantages:
  - Correlation maps already highlight related regions
  - SOM summarizes patterns
  - No requirement for orthogonality

Idealized Self Organizing Maps

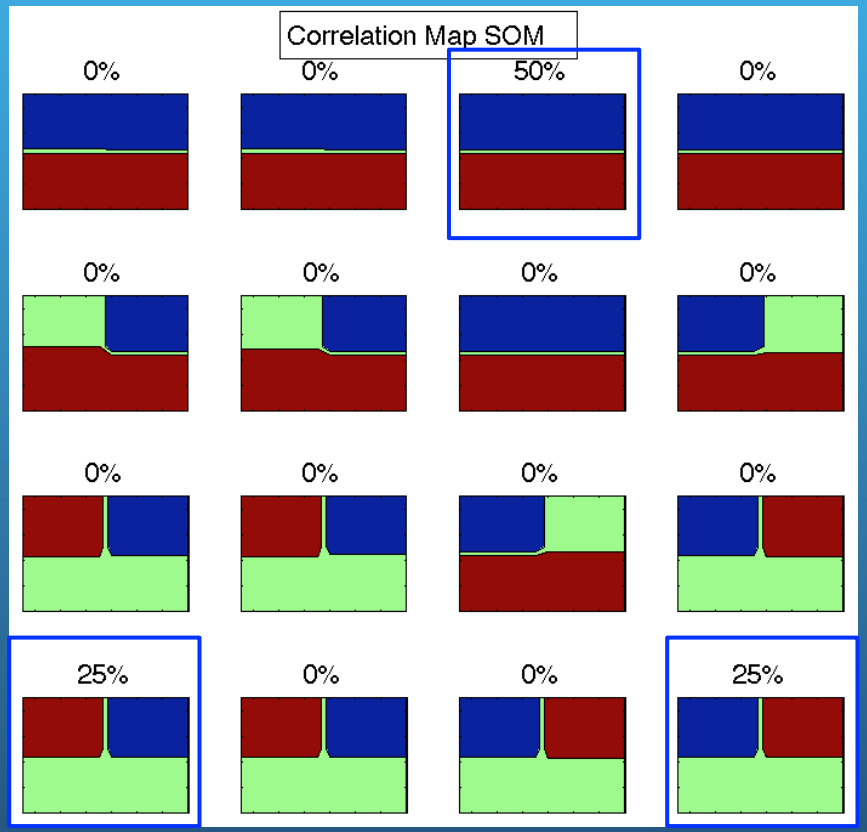


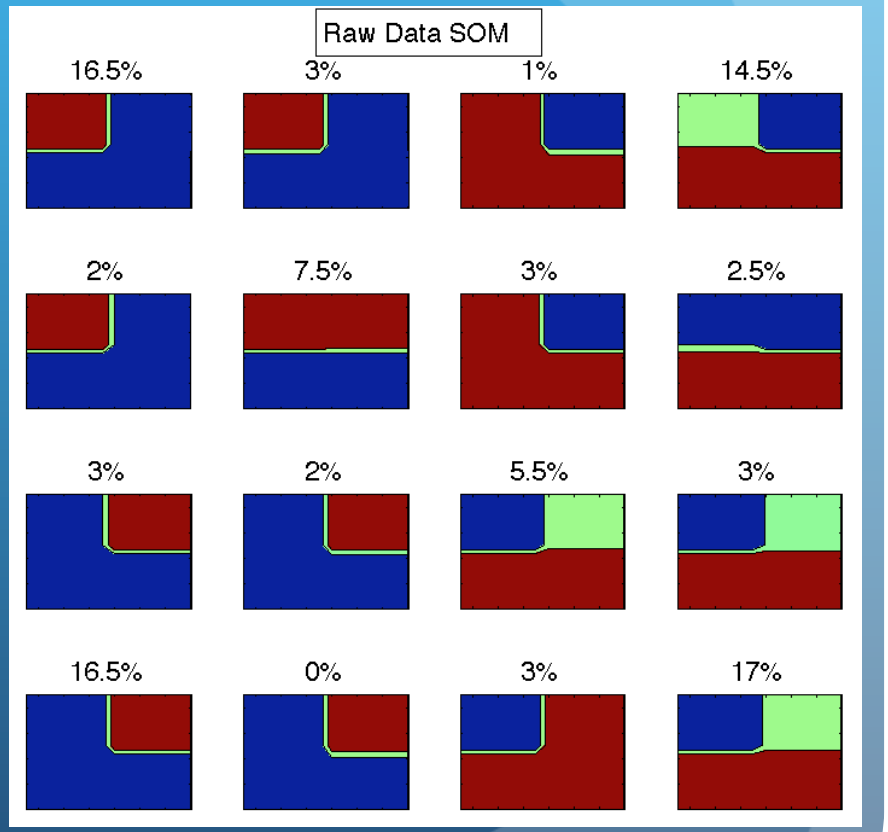
- Rectangular domain
- Simple north-south oscillation
- Plus east-west oscillation in northern half
- Add noise
- Construct point correlation maps for each grid point
- Present to 4 x 4 SOM
- Also SOM from raw data

Idealized SOM

Red = positive
Blue = negative
Green = zero

N-S oscillation, + E-W oscillation, no noise

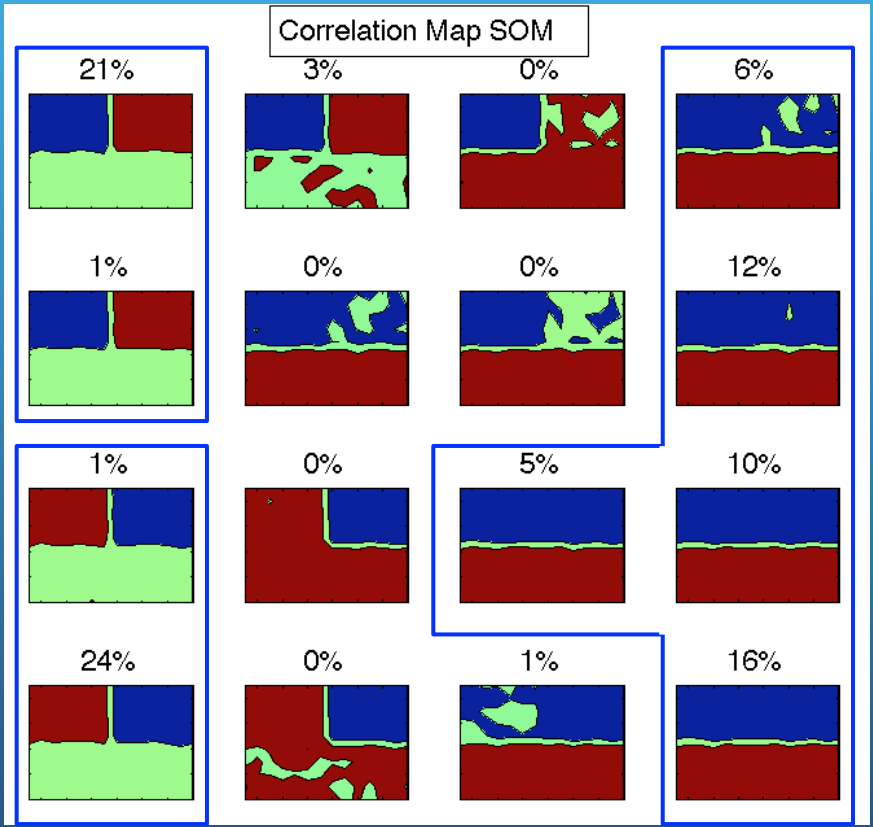


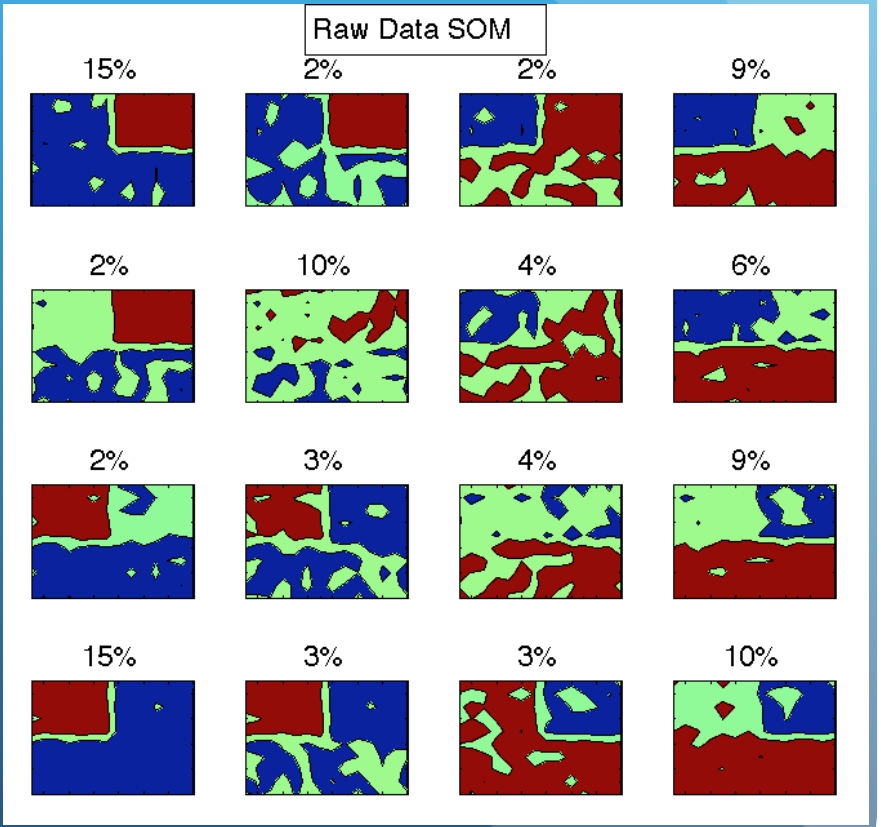


Idealized SOM

Red = positive
Blue = negative
Green = zero

N-S oscillation, + E-W oscillation, + white noise

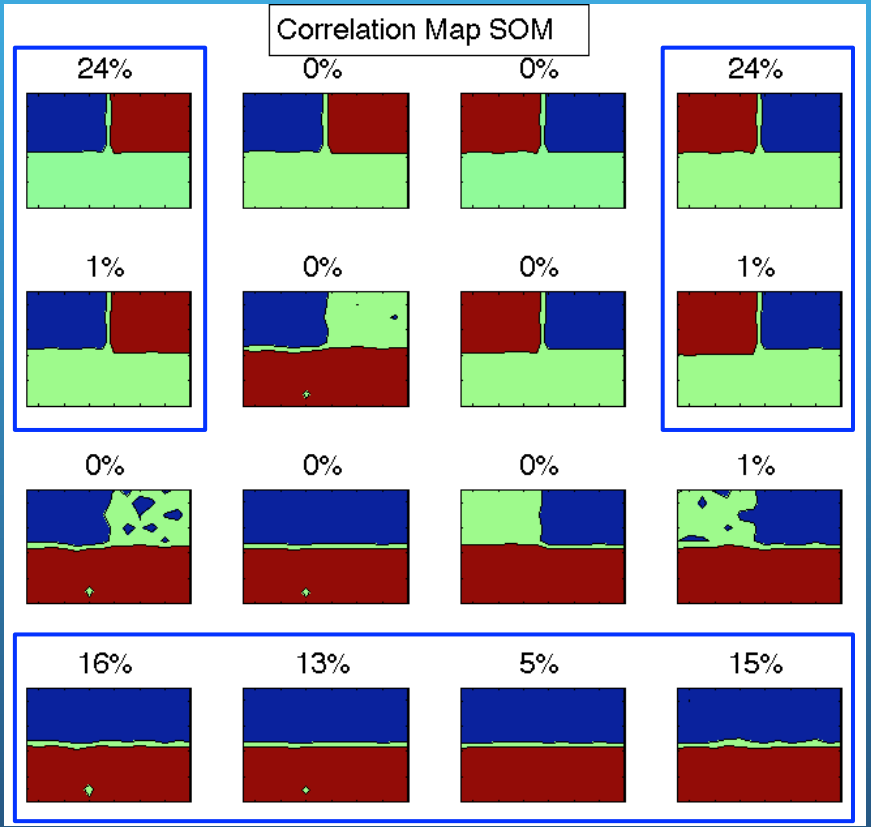


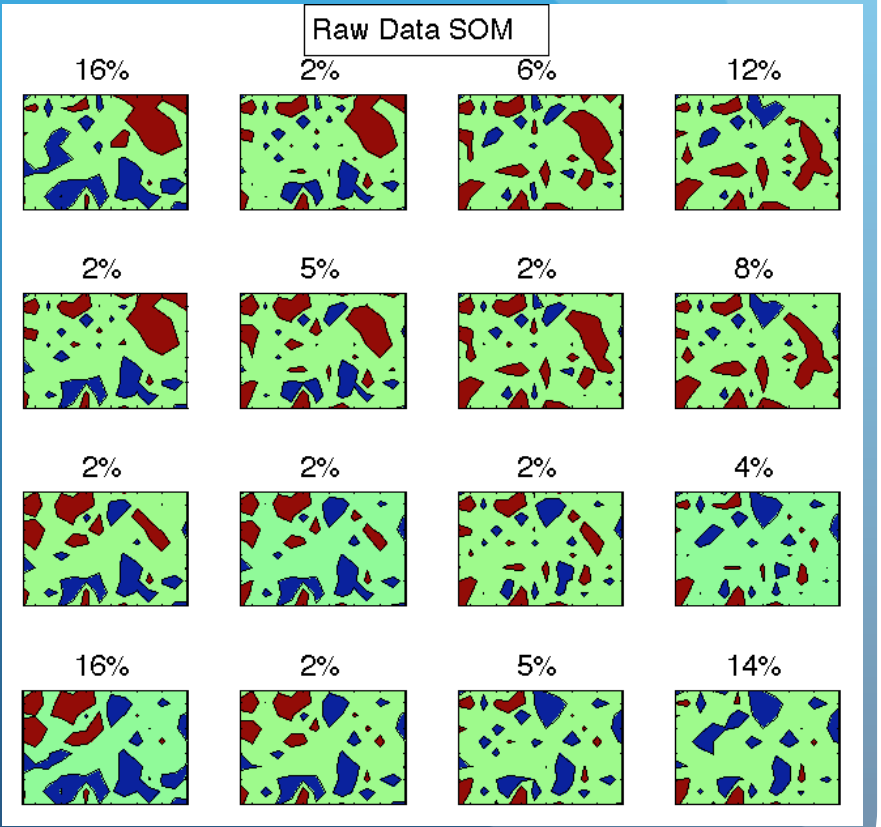


Idealized SOM

Red = positive
Blue = negative
Green = zero

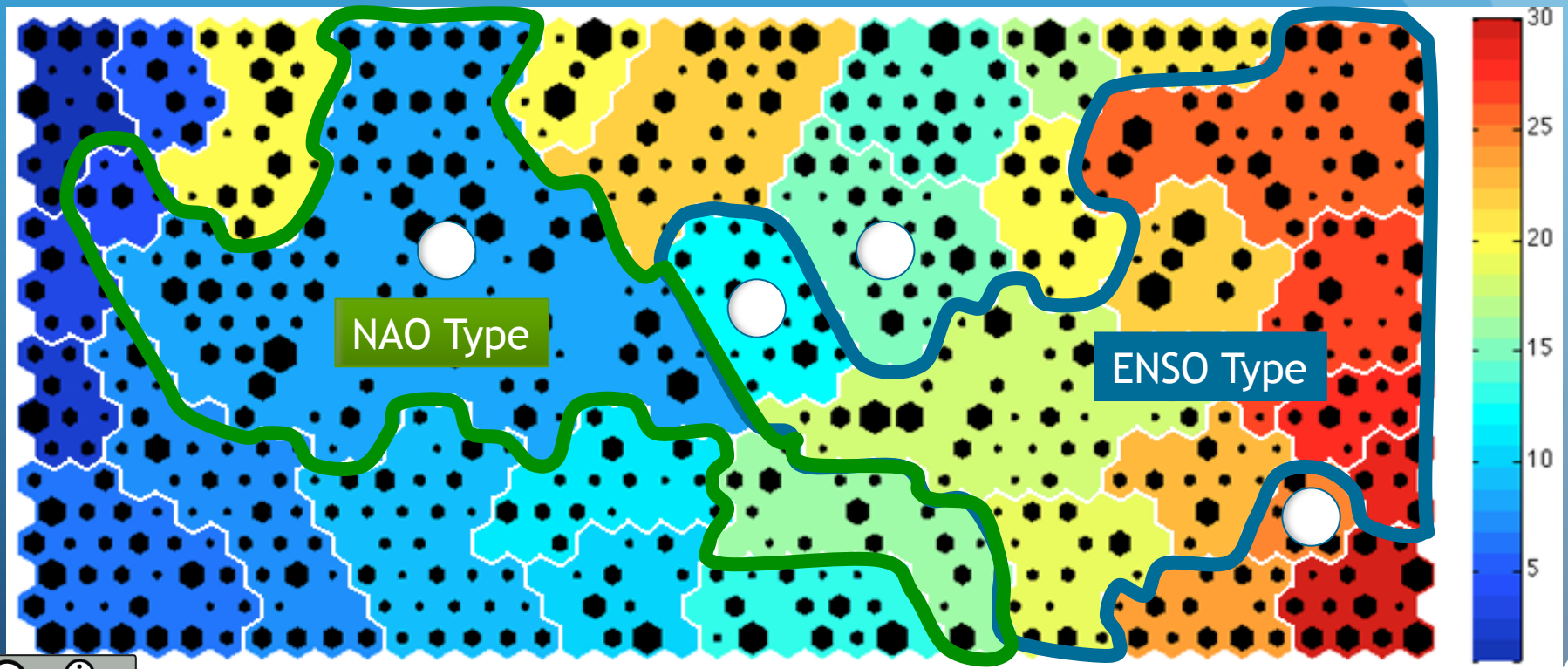
N-S oscillation, + E-W oscillation, + random walk

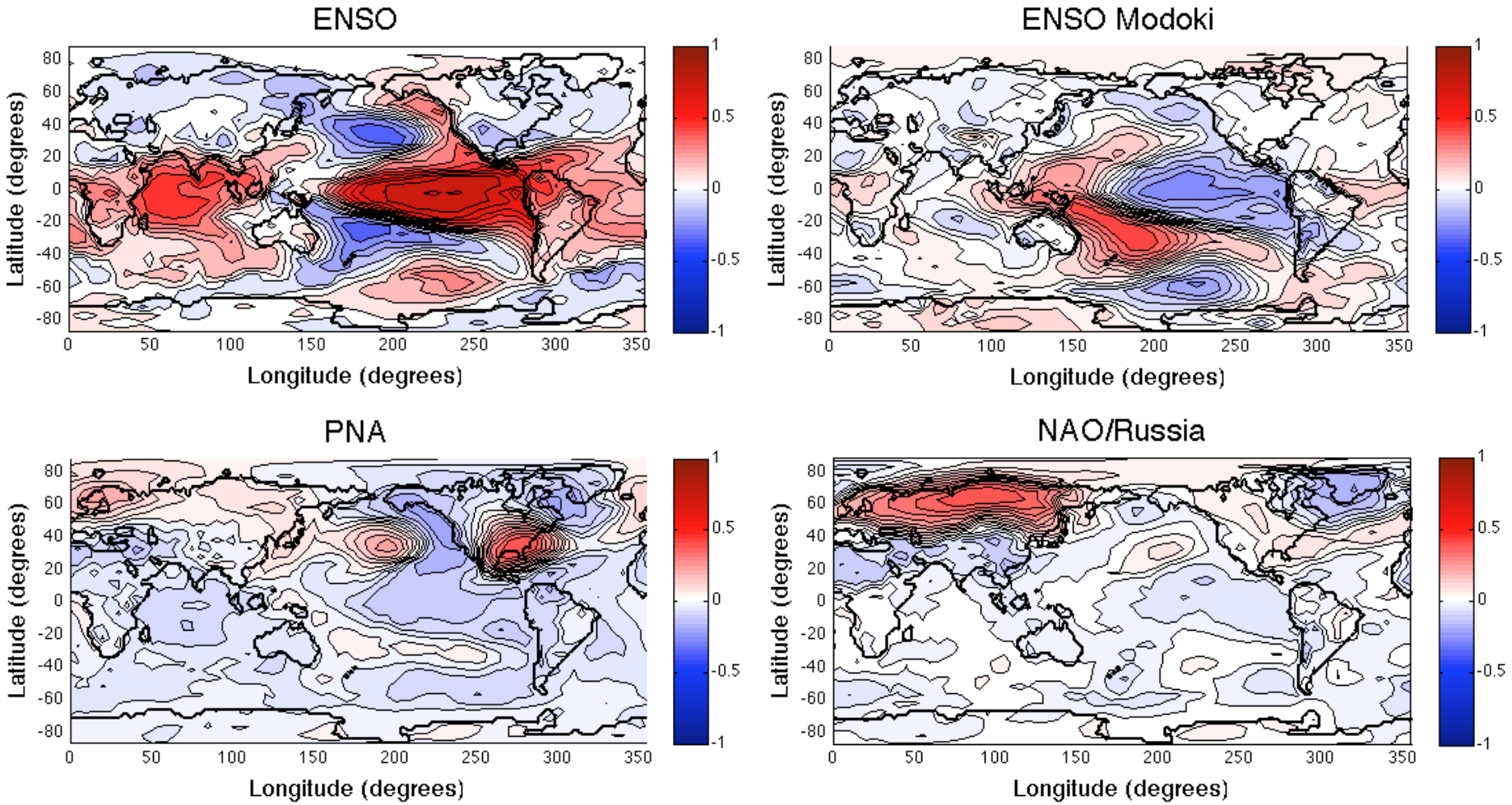




Temperature SOM

- 20 x 40 SOM - NCEP/NCAR monthly 2m temperature anomalies
- 1.1948 to 11.2008




ENSO
ENSO Modoki
PNA
NAO/Russia
Latitude (degrees)
Longitude (degrees)
80
60
40
20
0
-20
-40
-60
-80
0
50
100
150
200
250
300
350
1
0.5
0
-0.5
-1

Conclusions

- Correlation maps + SOMs effectively identify and summarize teleconnections
- Advantage over raw data as relationships already defined
- Advantage over EOFs as no orthogonality
- Flexible method – use comparison stage in many different ways to get different insights into large datasets
- Validating model behavior