Observations, Reanalyses and Ice Cores: Early Results from a Synthesis of Antarctic Climate

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The Transantarctic Mountains, A. Huerta, 2003

The "Big" Picture

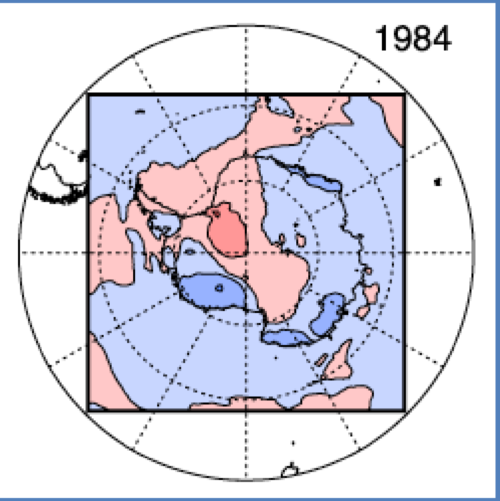
- Create a new picture of (West) Antarctic climate, recent and "paleo", using:
  - Data
    - Polar MM5 1979-2002 (modeling)
    - READER observations (meteorology)
    - Ice cores (paleoclimate)
  - Artificial neural network (ANN) techniques
- Pilot study underway…

Methods Overview

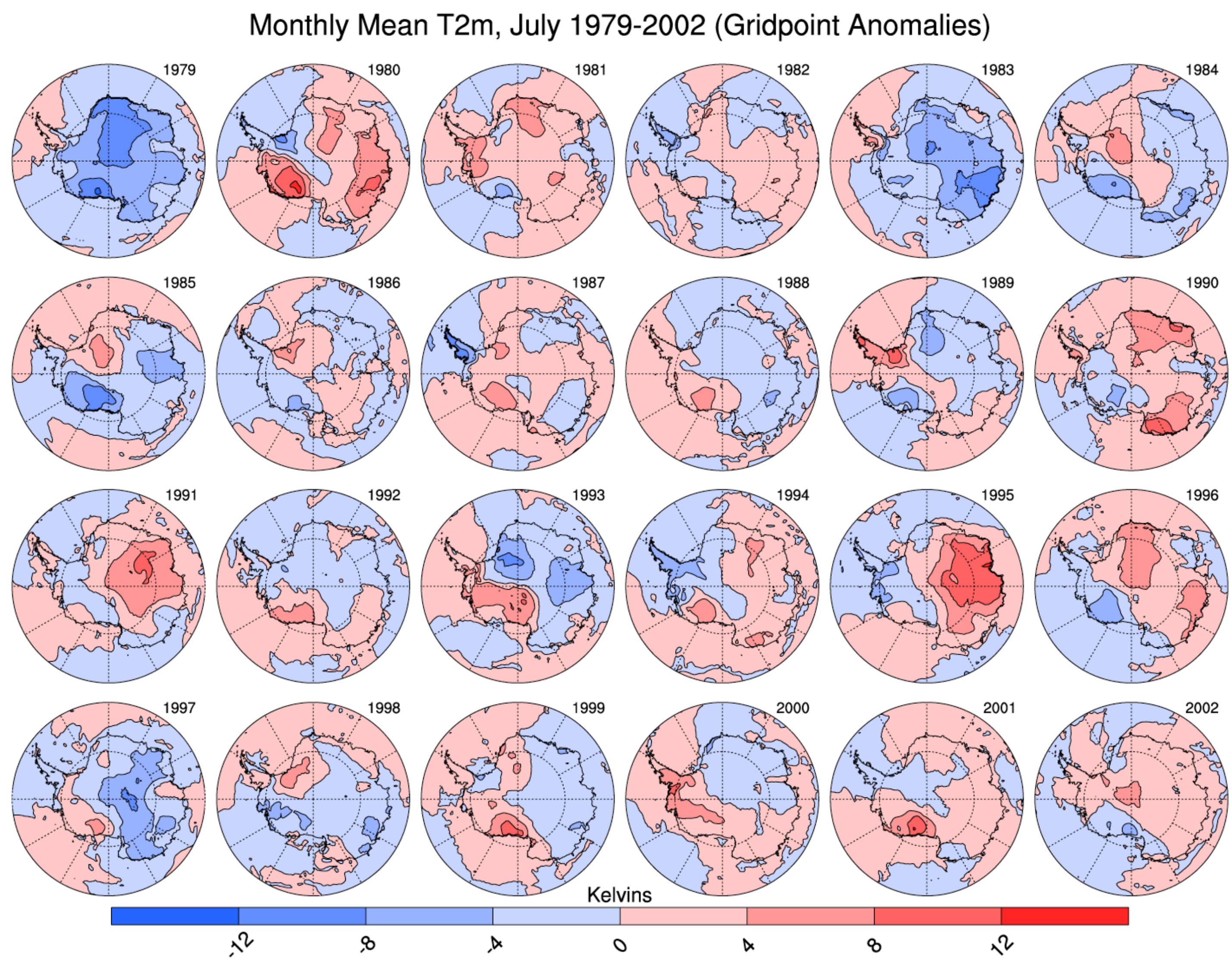
- Self-organizing maps (SOMs) to summarize variability in meteorology
  - Definitely for model data
  - Possibly for READER observations
- Neural networks to
  - Relate SOM results to ice cores and build ice core-based meteorological reconstructions
  - Possibly fill gaps in observational records

The Model Dataset

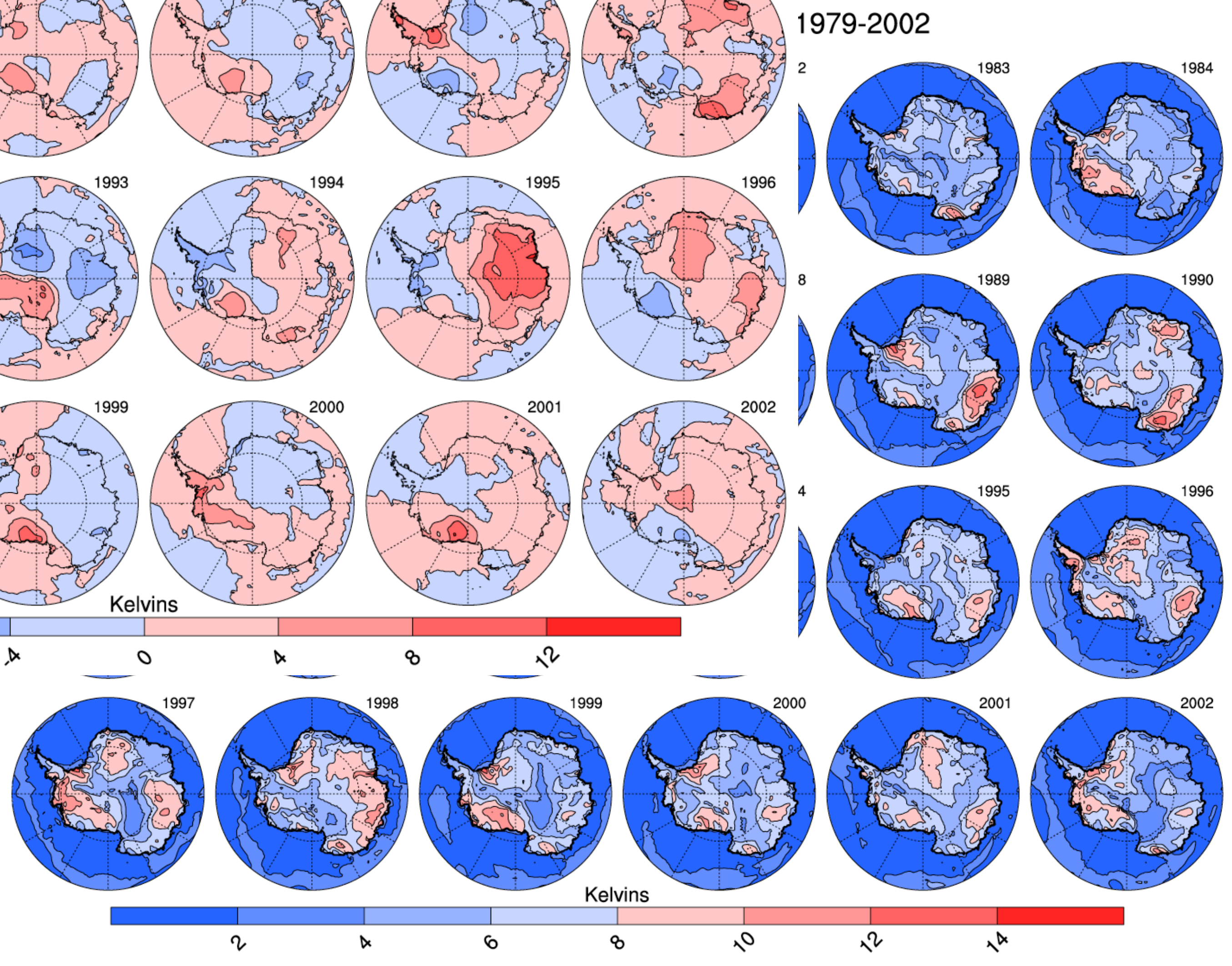
- Andy Monaghan’s ~24-year Polar MM5
  - Externally driven by ERA-40, 6-hourly
  - Jan 1979 - Aug 2002
  - 60 km grid
- Pilot Study
  - Daily July T-2m (744 days)
  - Standard SOM-based analyses
  - Relate to READER observations



Grid Domain



Monthly Mean



Monthly Standard Deviation

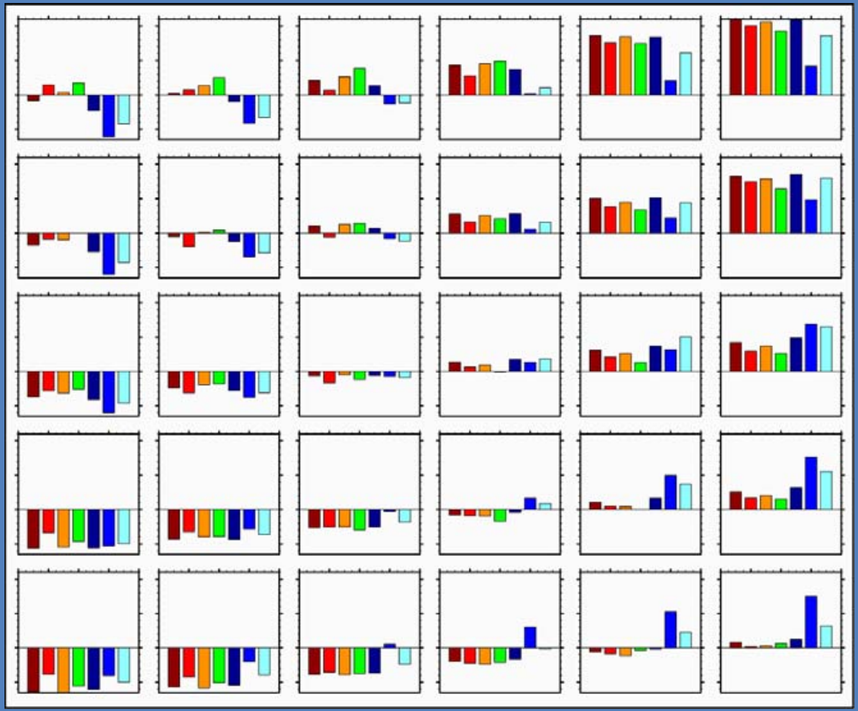
Self-organizing Maps (SOMs)

1) Concise summary of data variability expressed as a user-defined number of generalized patterns

Patterns arranged in a grid by their relative similarity

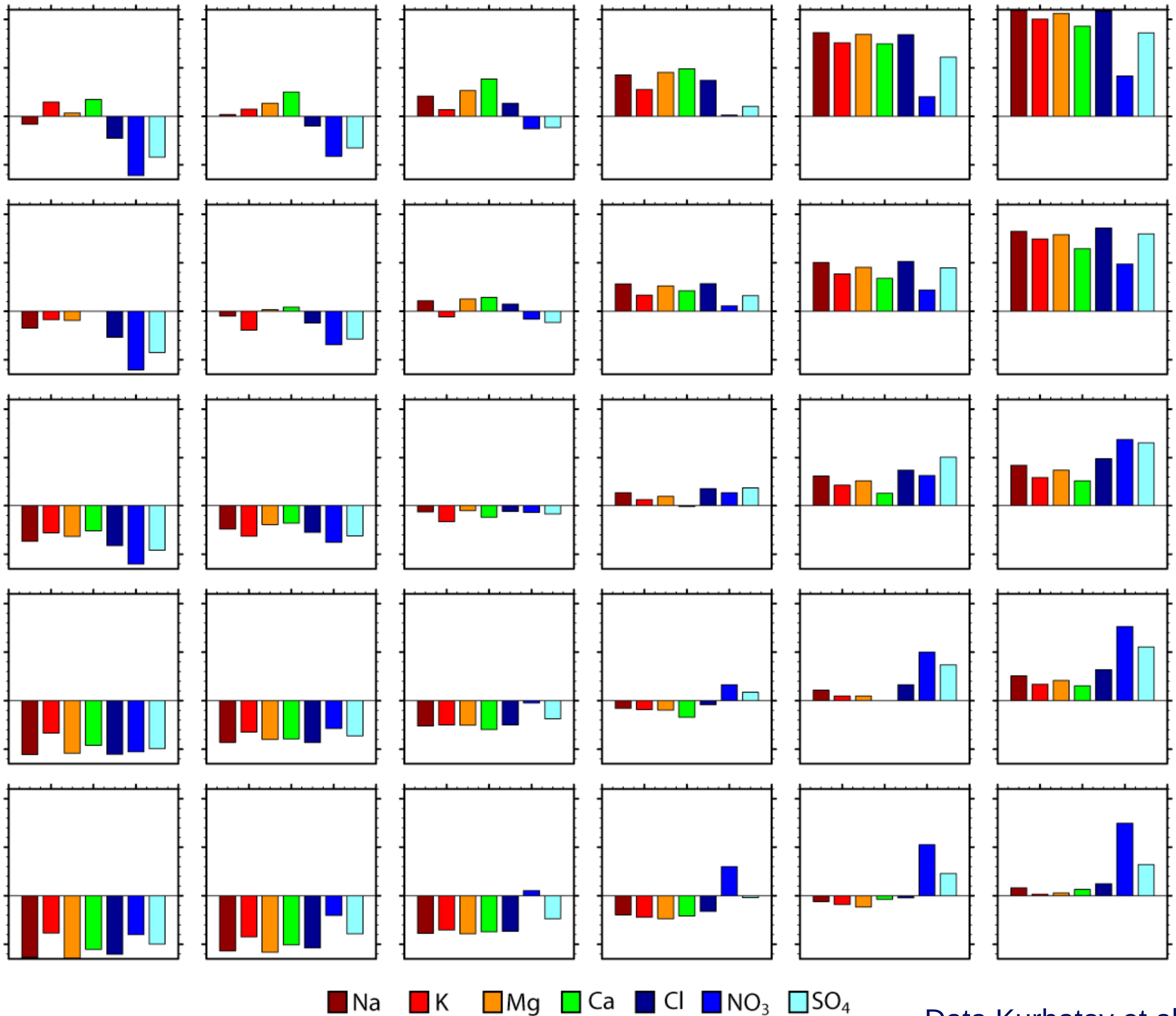
Patterns tend to change smoothly across rows/columns

A projection (mapping) from the multidimensional input space to the 2-D pattern space

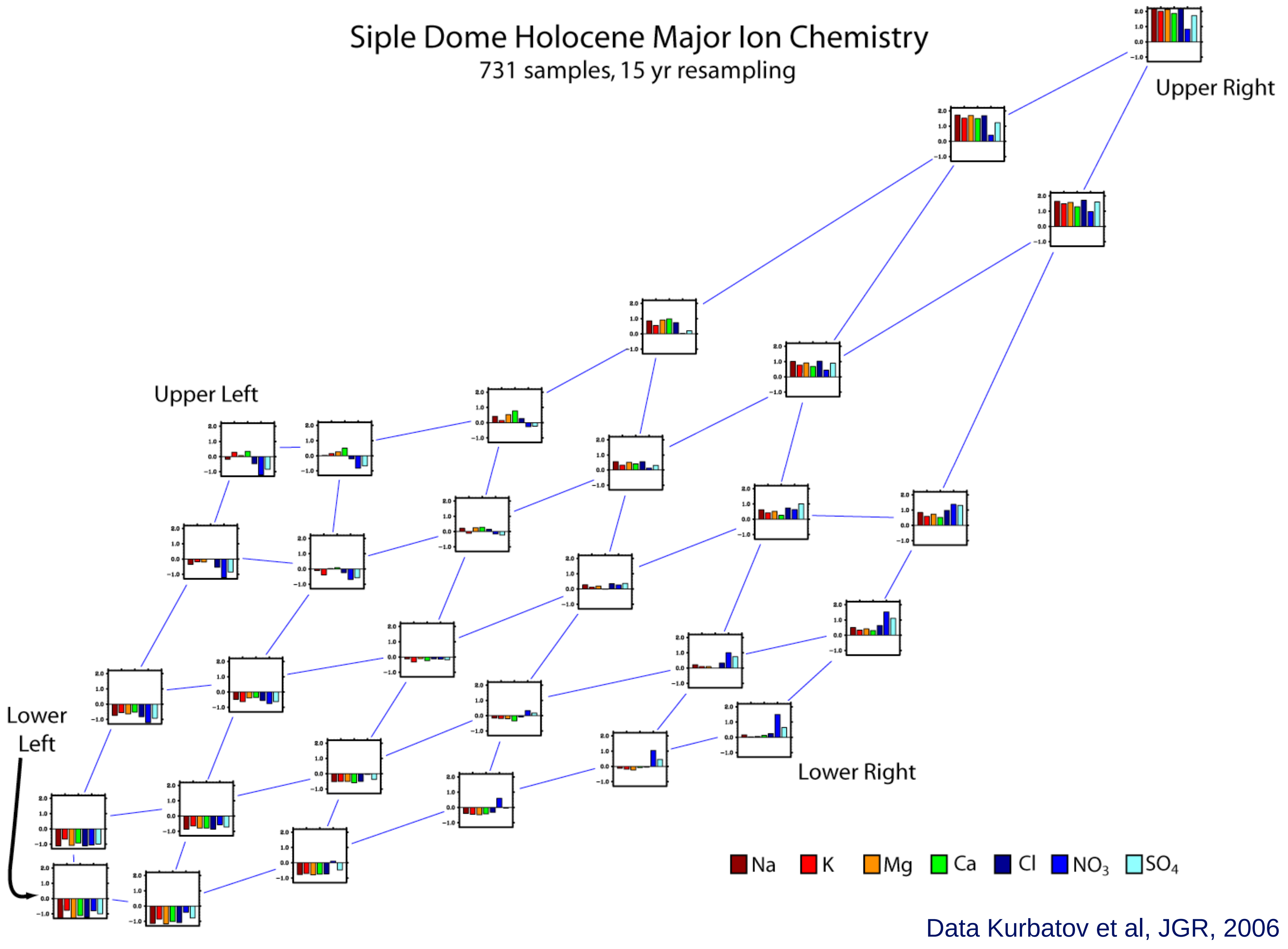


Holocene ice core chemistry

Siple Dome Holocene Major Ion Chemistry



Data Kurbatov et al, JGR, 2006



Siple Dome Holocene Major Ion Chemistry
731 samples, 15 yr resampling
Upper Right
Upper Left
Lower Left
Lower Right
Na
K
Mg
Ca
Cl
NO3
SO4
Data Kurbatov et al, JGR, 2006

Self-organizing Maps (SOMs)

2) Also used for classifying multivariate data and studying its temporal behavior

Each input record matches one pattern most closely

Records matching the same pattern have it in common

Basis for frequency, transition and trajectory maps

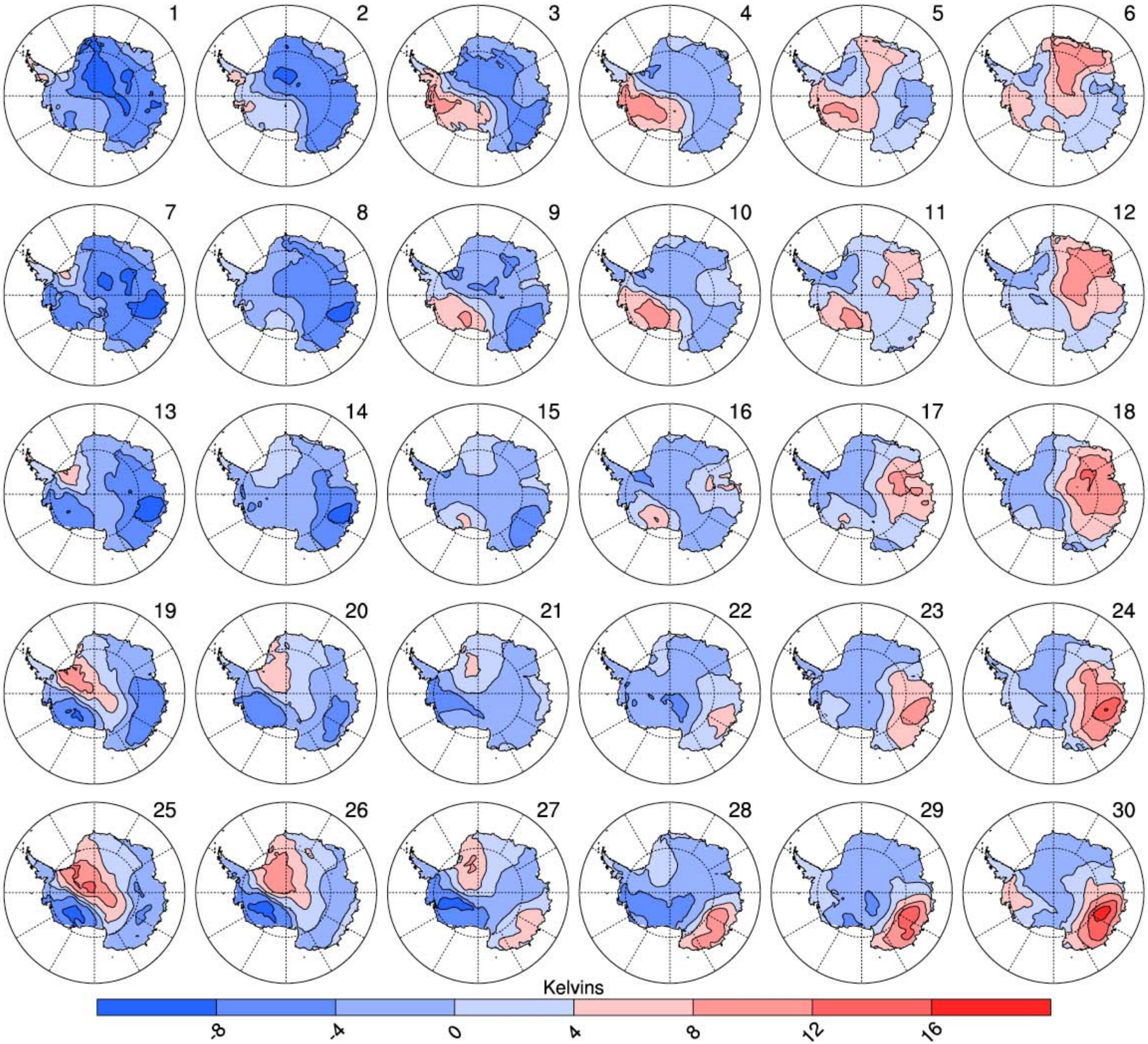
11	6	5	4	2	5
1	5	2	3	2	4
4	5	5	3	5	5
4	6	3	4	3	5
9	5	5	3	6	5

A Frequency Map

Early Results

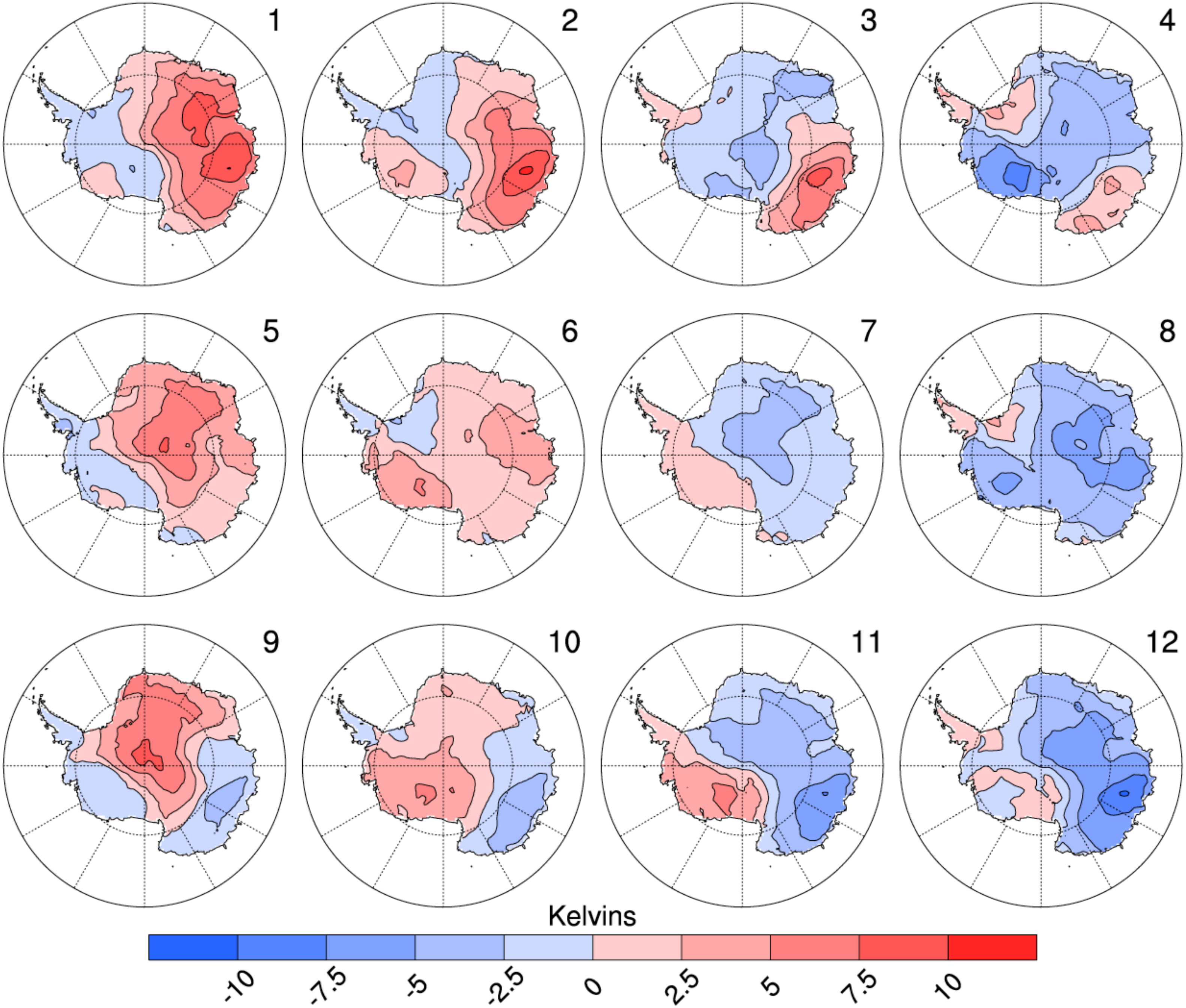
- Patterns and Frequency Changes
- A “Preferred” Transition Path?
- Comparison to READER Observations

6x5 SOM of Daily Temperature (Anomalies)

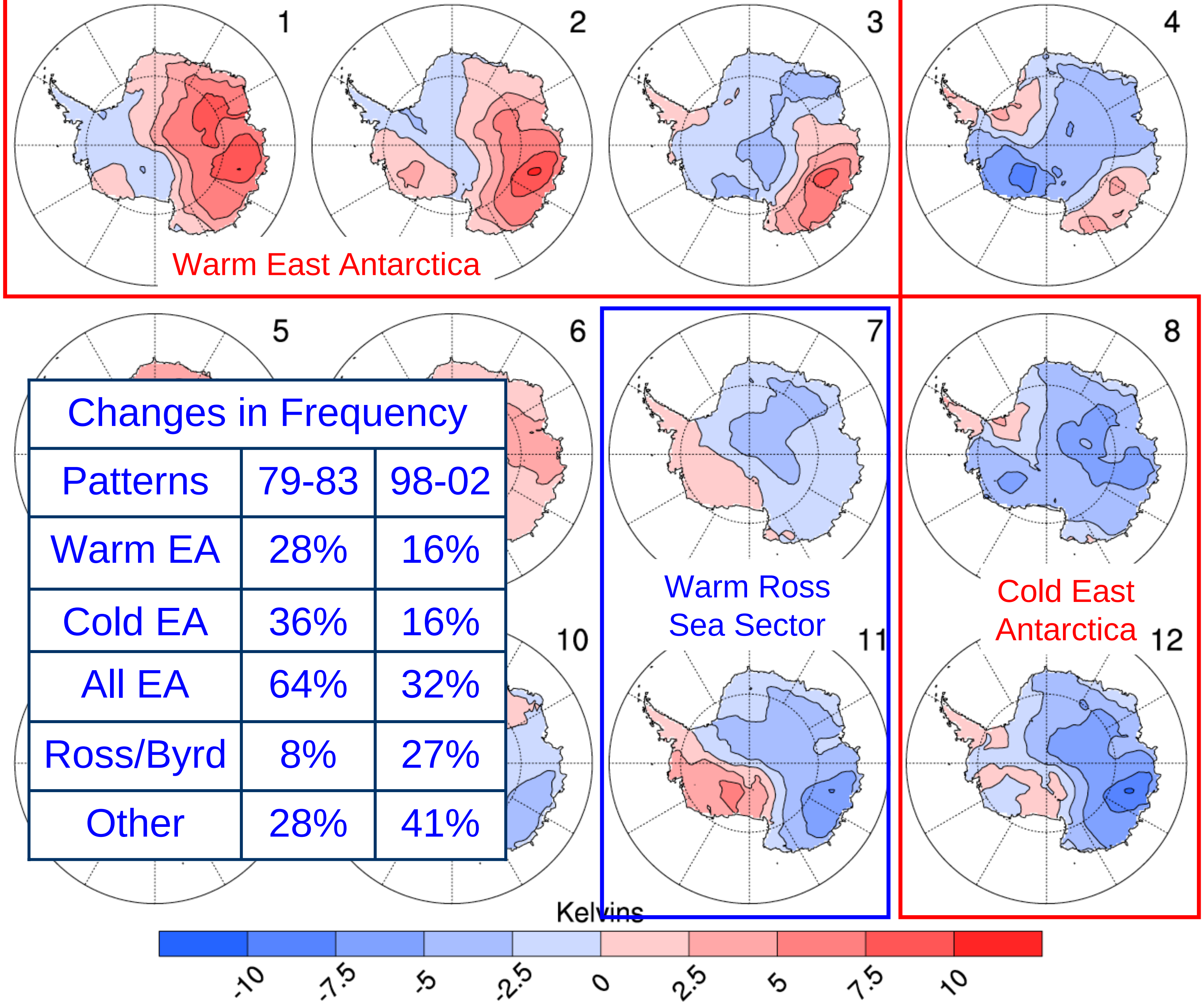


Patterns and Frequency & Transitions & READER

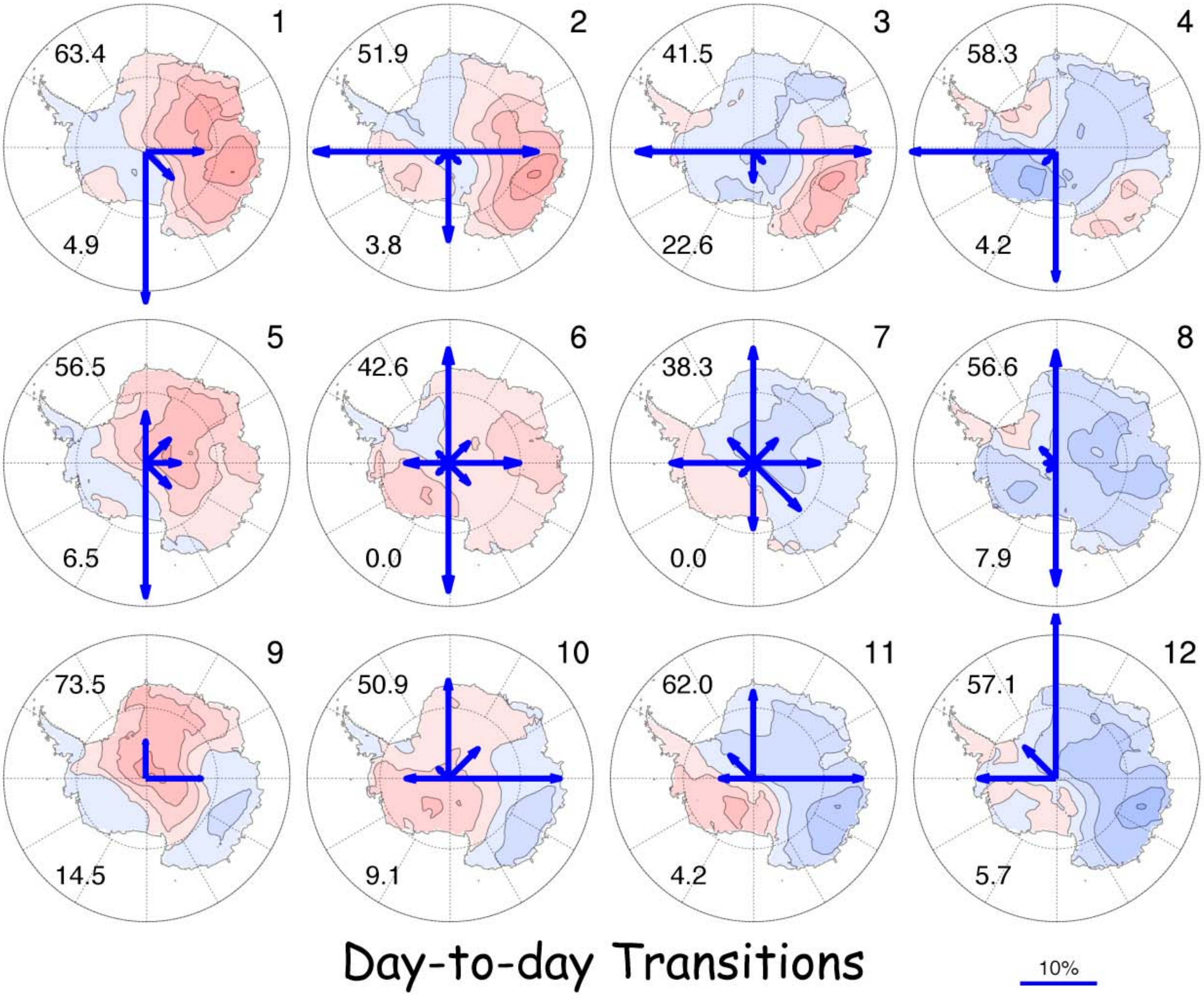
4x3 SOM of Daily Temperature (Anomalies)



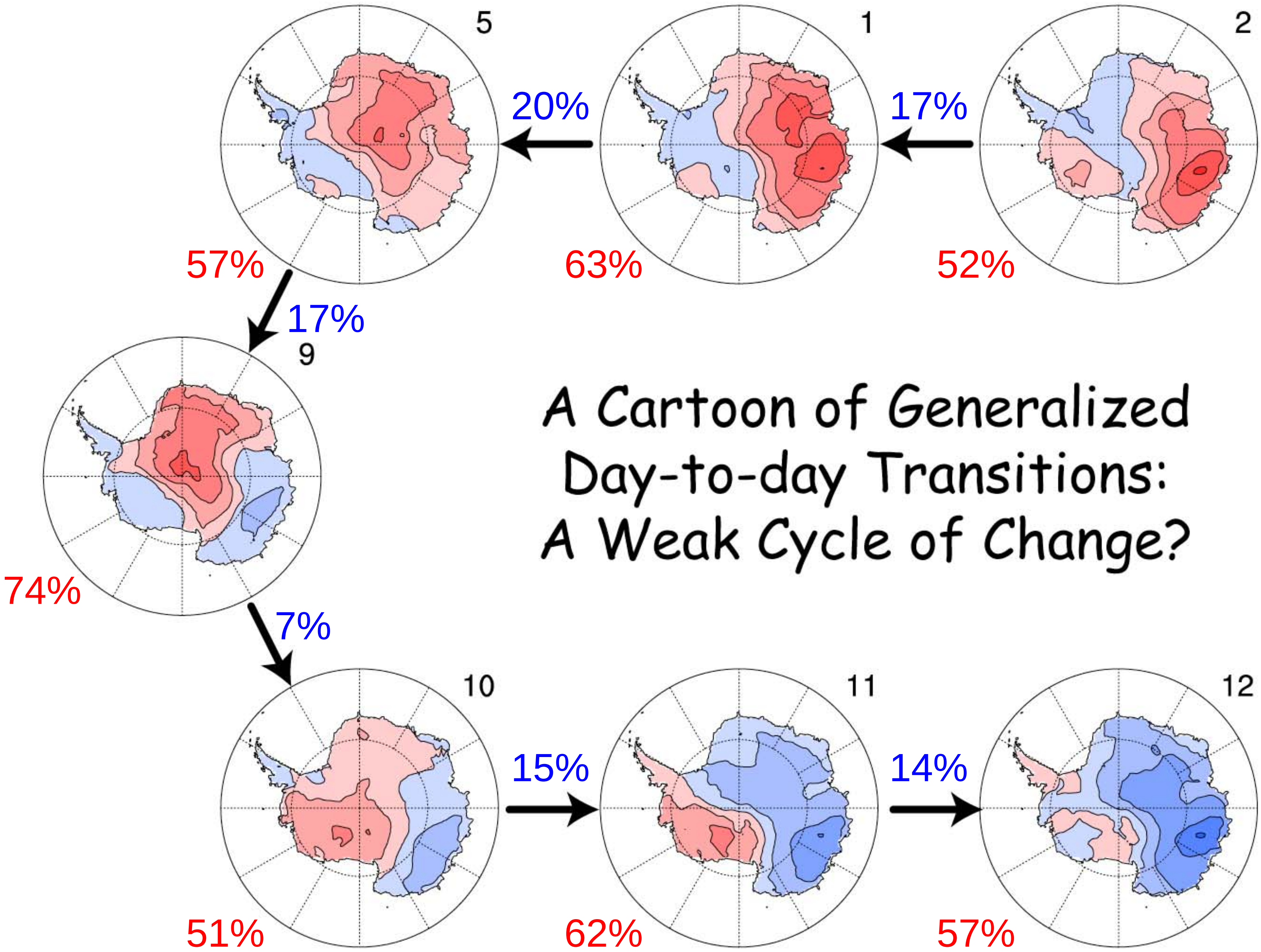
Patterns and Frequency & Transitions & READER

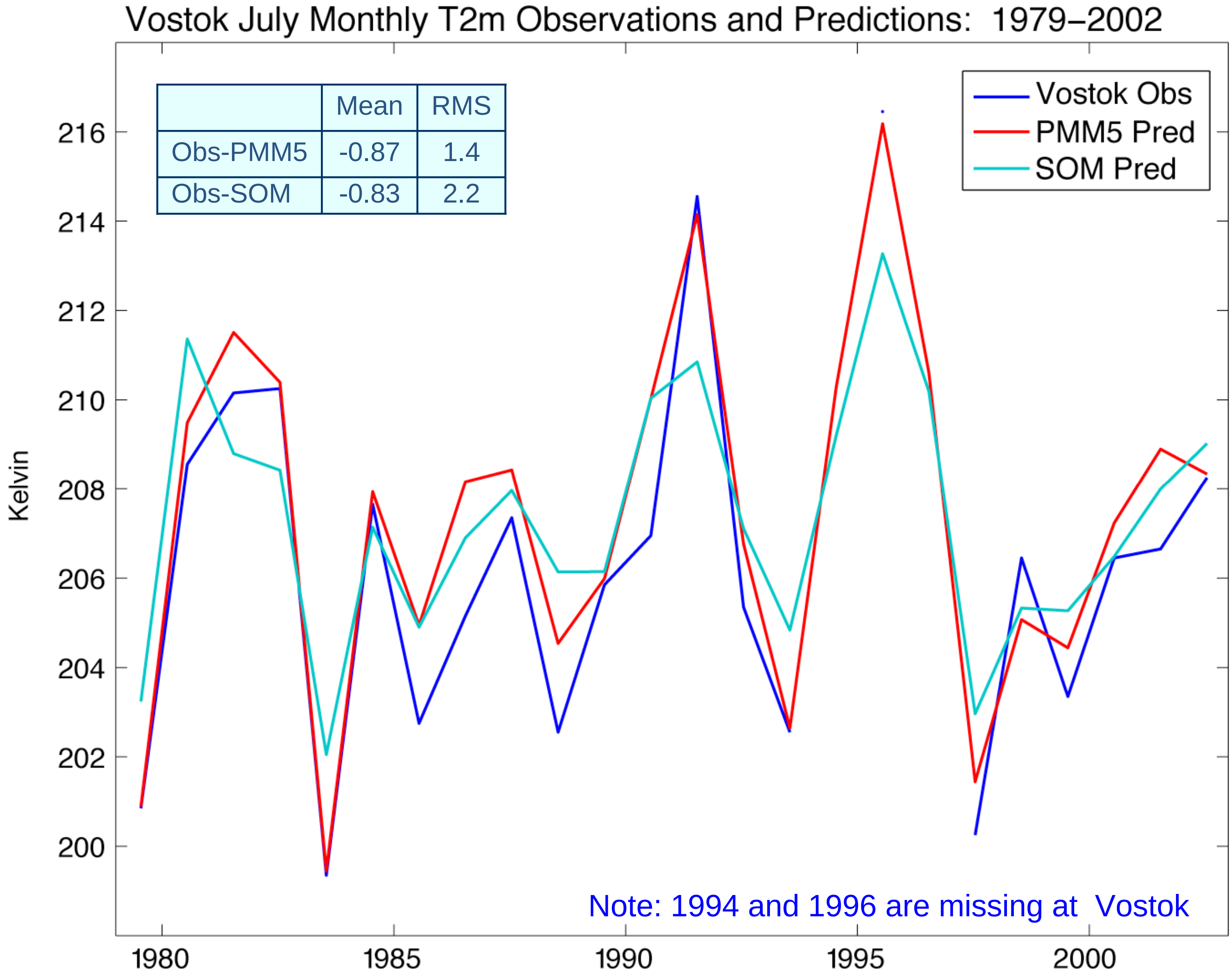


Changes in Frequency		
Patterns	79-83	98-02
Warm EA	28%	16%
Cold EA	36%	16%
All EA	64%	32%
Ross/Byrd	8%	27%
Other	28%	41%



Patterns and Frequency & Transitions & READER


5
1
2
20%
17%
57%
63%
52%
17%
9
A Cartoon of Generalized Day-to-day Transitions: A Weak Cycle of Change?
74%
7%
10
11
12
15%
14%
51%
62%
57%

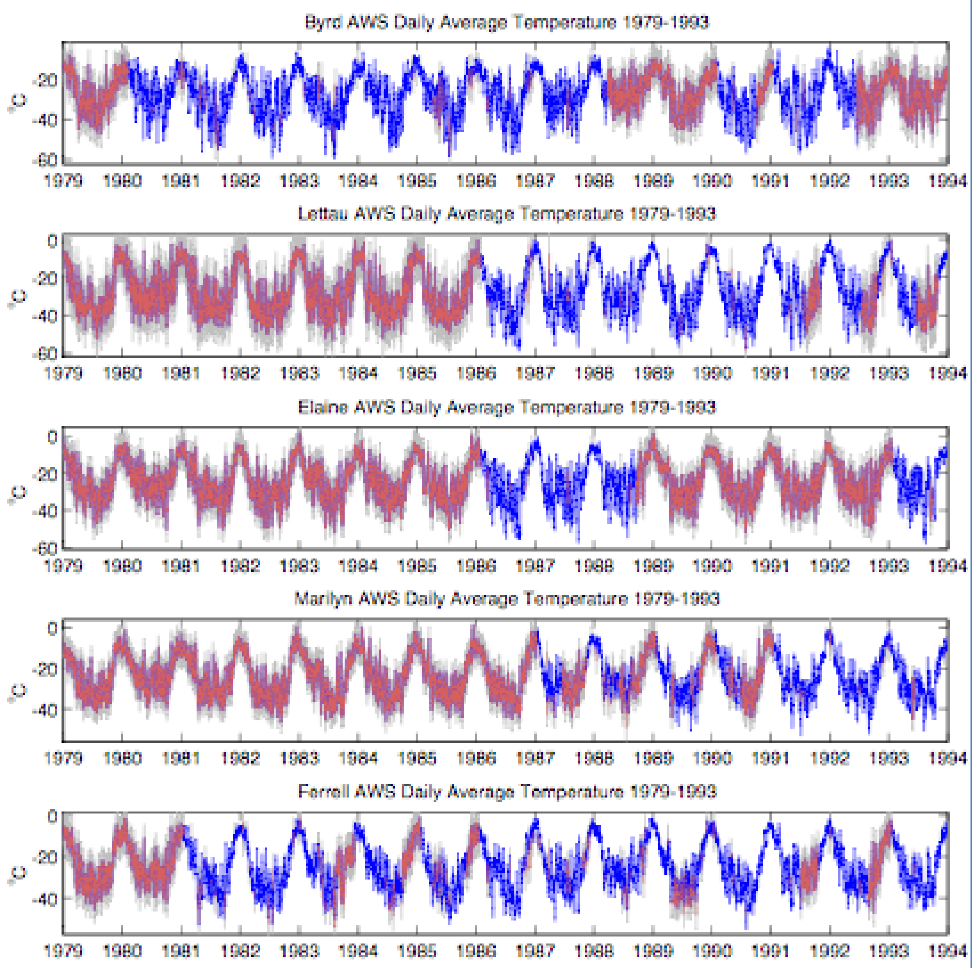

Vostok July Monthly T2m Observations and Predictions: 1979–2002
Mean
RMS
Obs-PMM5
-0.87
1.4
Obs-SOM
-0.83
2.2
Vostok Obs
PMM5 Pred
SOM Pred
Kelvin
216
214
212
210
208
206
204
202
200
1980
1985
1990
1995
2000
Note: 1994 and 1996 are missing at Vostok

Future Work

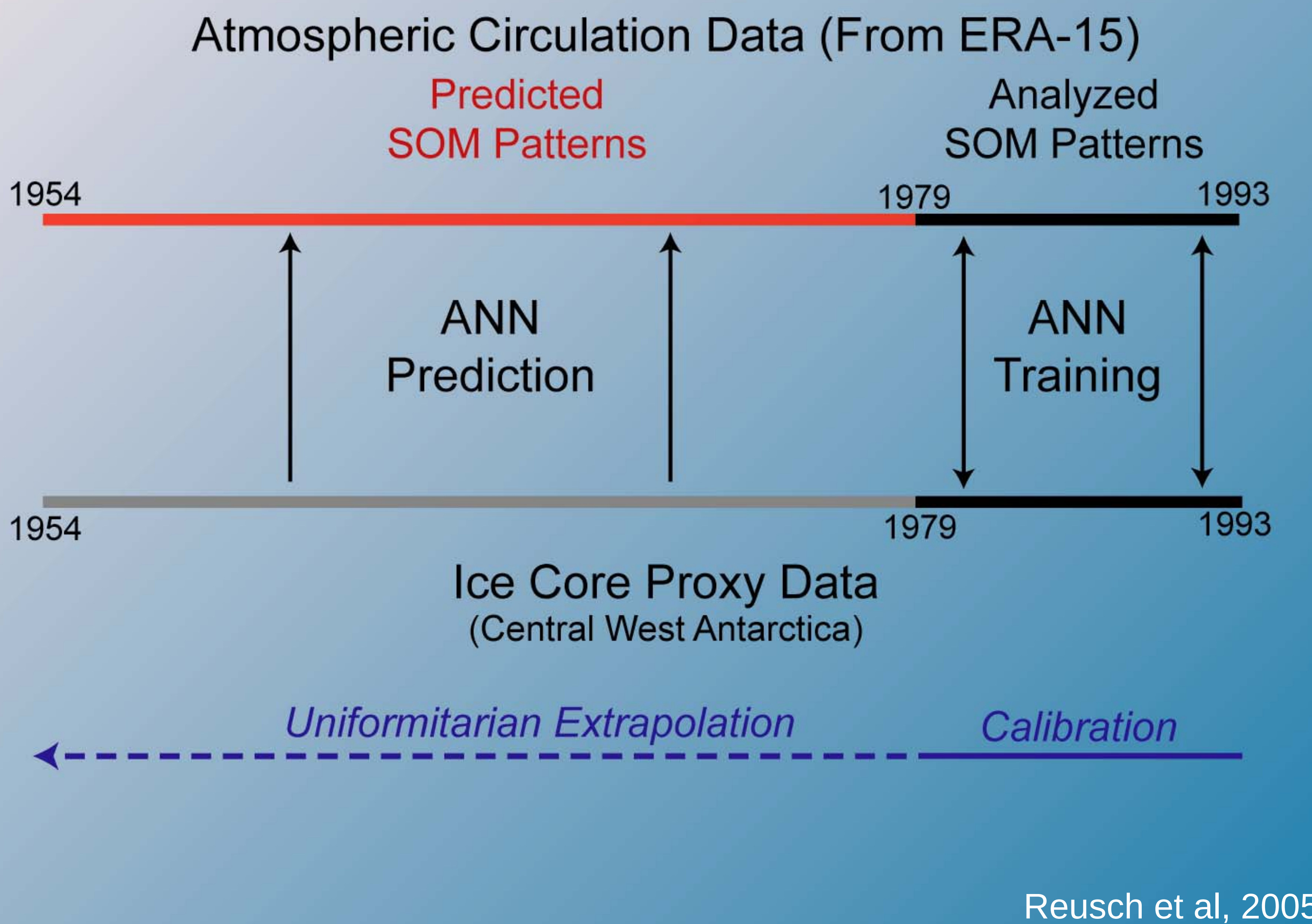
- Expand PMM5 analyses to other vars and longer timescales (more “climate”…)
- Explore READER “fill-ins”
- Ice core-based reconstructions

READER “Fill in”

- Train a NN to predict observations using some other data always available (e.g., ERA-40)
- Use trained NN to predict what would have been observed
- Limited to period of the external data

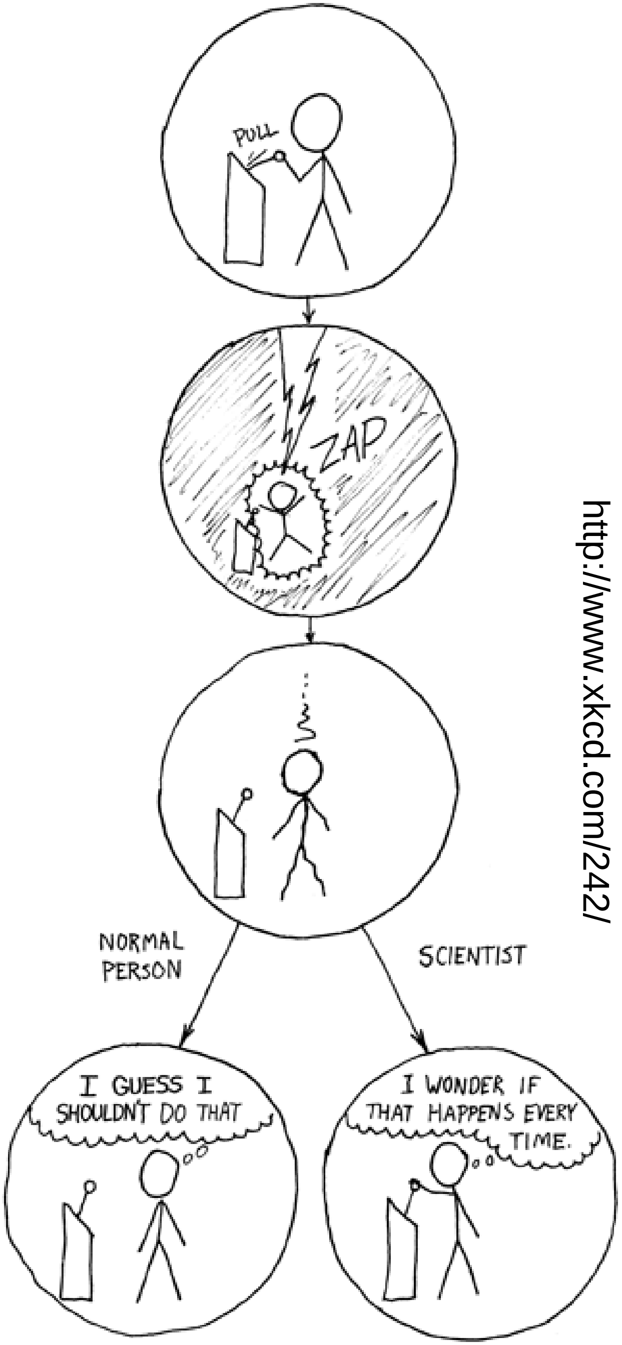


AWS Reconstructions
Reusch and Alley, 2002, 2004


Atmospheric Circulation Data (From ERA-15)
Predicted
SOM Patterns
Analyzed
SOM Patterns
1954
1979
1993
ANN
Prediction
ANN
Training
1954
1979
1993
Ice Core Proxy Data
(Central West Antarctica)
Uniformitarian Extrapolation
Calibration
Reusch et al, 2005

Conclusions

- Pilot has shown value of SOMs in analysis of PMM5 temperature at daily scale
- One READER comparison looks good
- Still much to do!



http://www.xkcd.com/242/