Understanding Synoptic Weather Yielding Extreme Daily Precipitation

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Understanding Synoptic Weather Yielding Extreme Daily Precipitation

Goal here: synoptic climatology of extreme events

- ★ discriminate different types of events
- ★ diagnose physical causes and outcomes
- ★ reveal frequency of types

How does one construct representative, collective behavior?

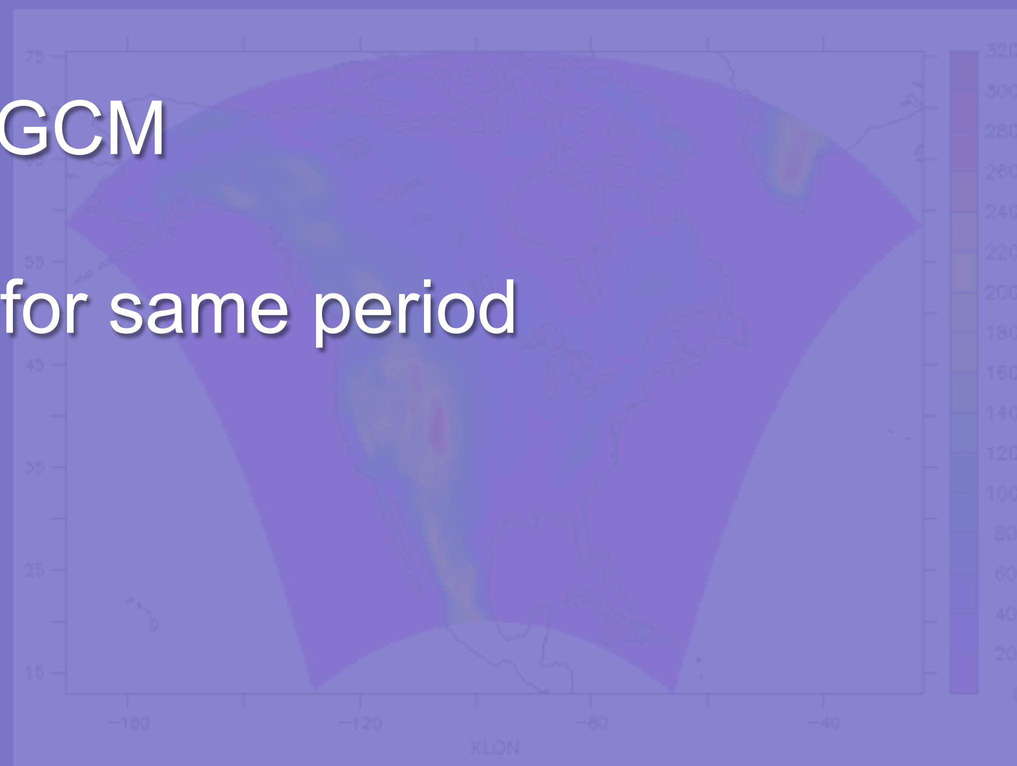
Two examples:

**(1) A simple case:
testing of
composites**

**(2) More complex: using
Self-Organizing
Maps (SOMs)**

NARCCAP Simulations

MM5	RegCM3	CRCM	HADRM3	RSM	WRF
Iowa State/ PNNL	UC Santa Cruz ICTP	Quebec, Ouranos	Hadley Centre	Scripps	NCAR/ PNNL



PLUS:

GFDL Atmosphere GCM

- 0.5˚ resolution

- specified SST/ice for same period

Diagnosis

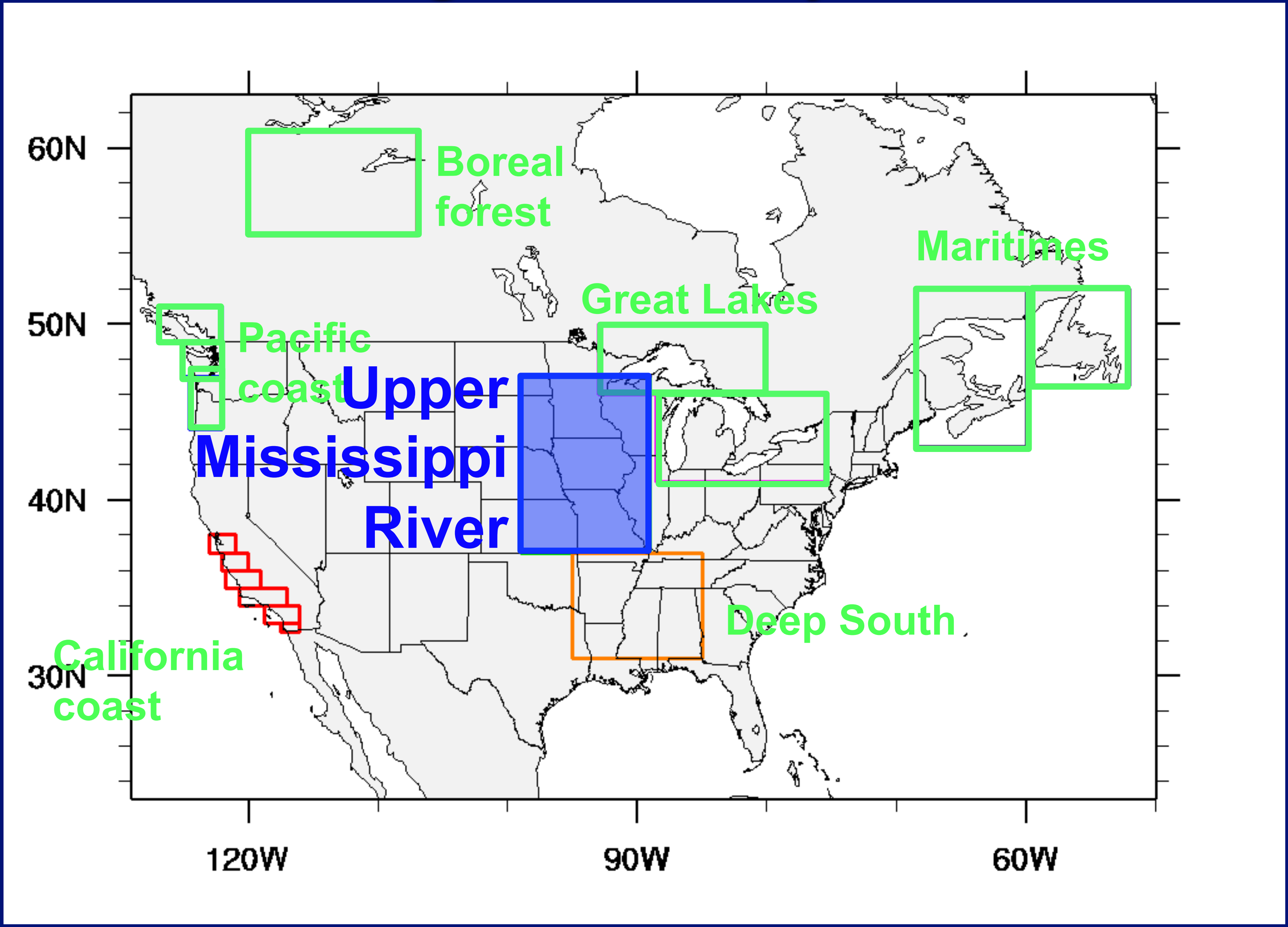
- Observation-based Fields
  - Precip: University of Washington VIC retrospective analysis
  - Other fields: North American Regional Reanalysis

- Comparison period: 1982 -1999
  - 1979-1981 omitted for RCM spinup
  - UW data end in mid-2000

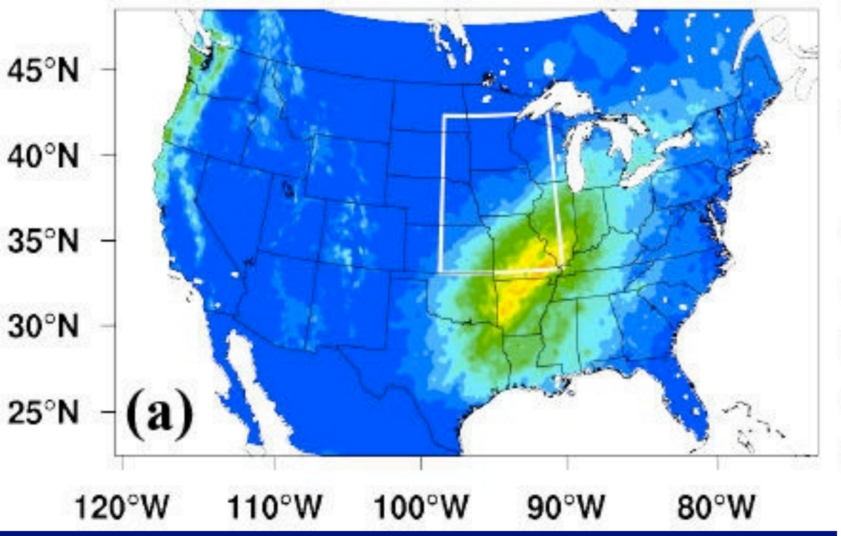
- Analysis
  - "Precipitation event" = Daily precip ≥ 2.5 mm at a grid point
  - Focus on precip intensity ≥ 99.5%
  - Pool all "events" in the target region

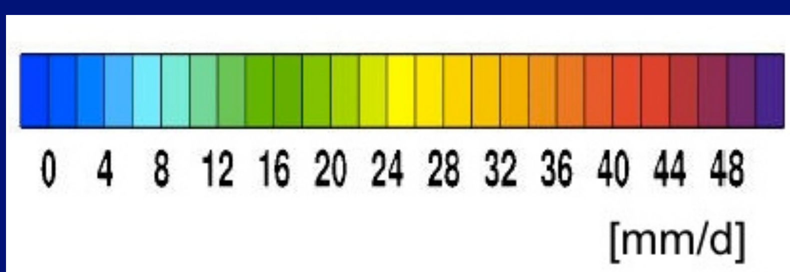
(Kawazoe, S., and Gutowski, W., 2013, *J. Hydrometeorology*)

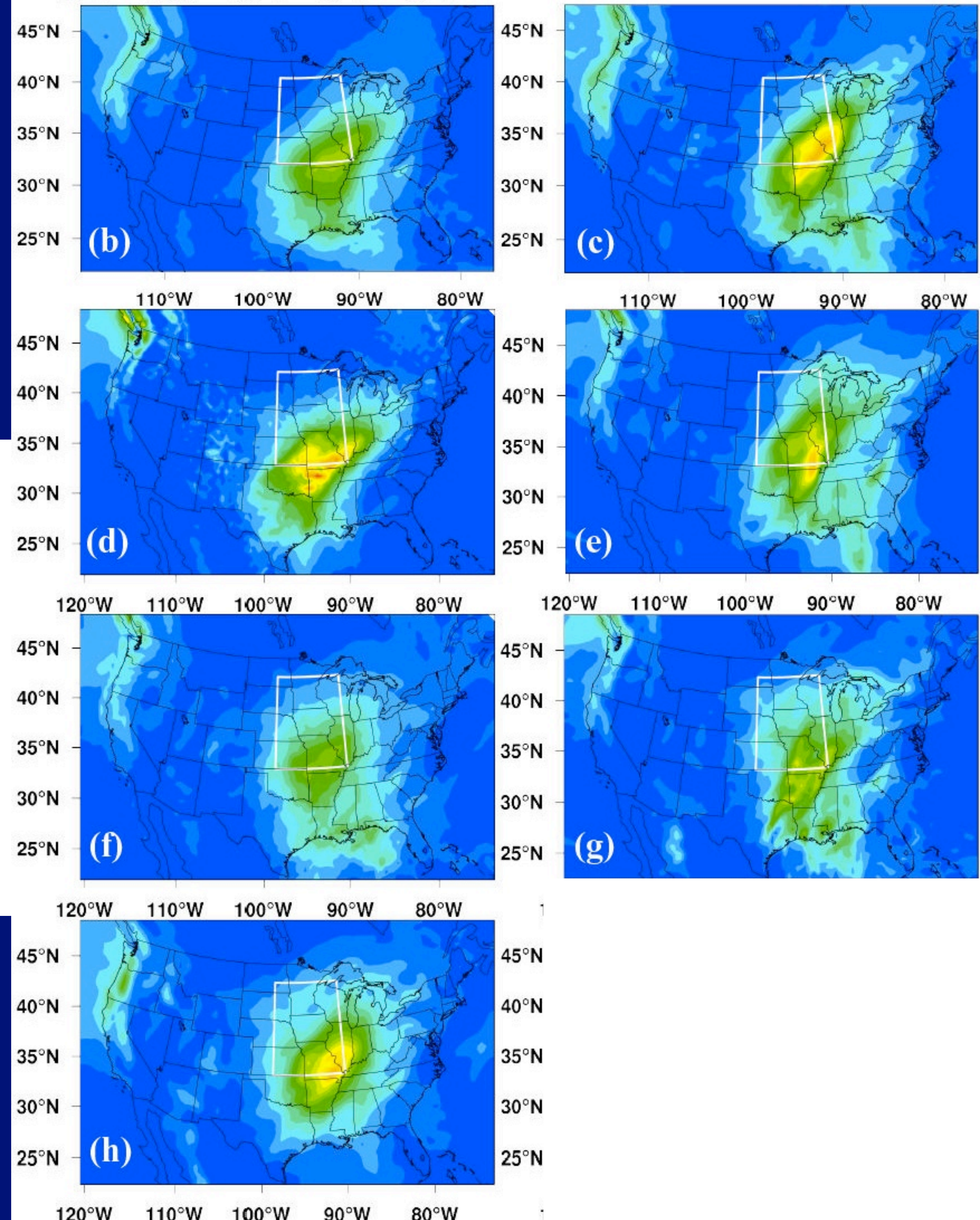
Region Analyzed



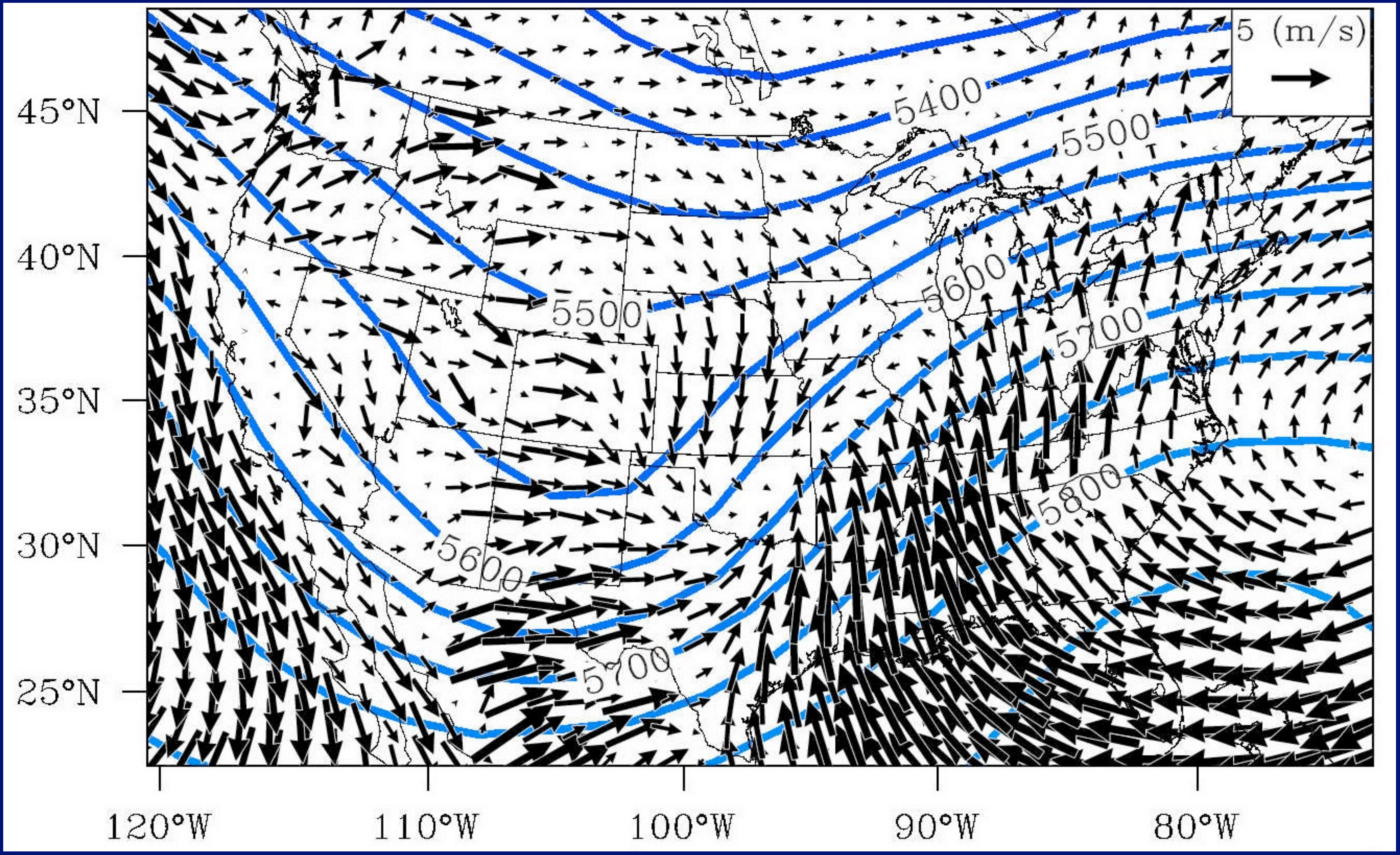
Composite Structure of Extreme Events: DJF Precipitation



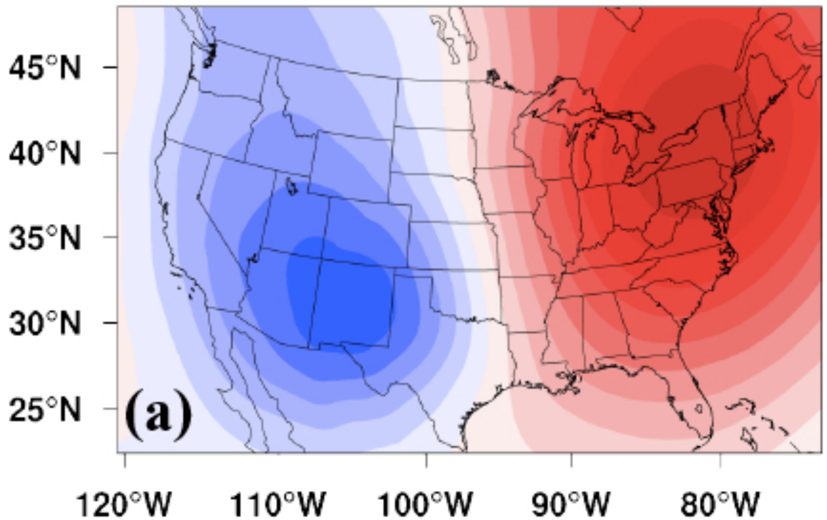


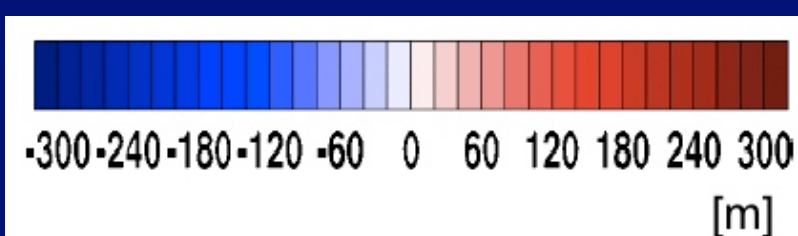


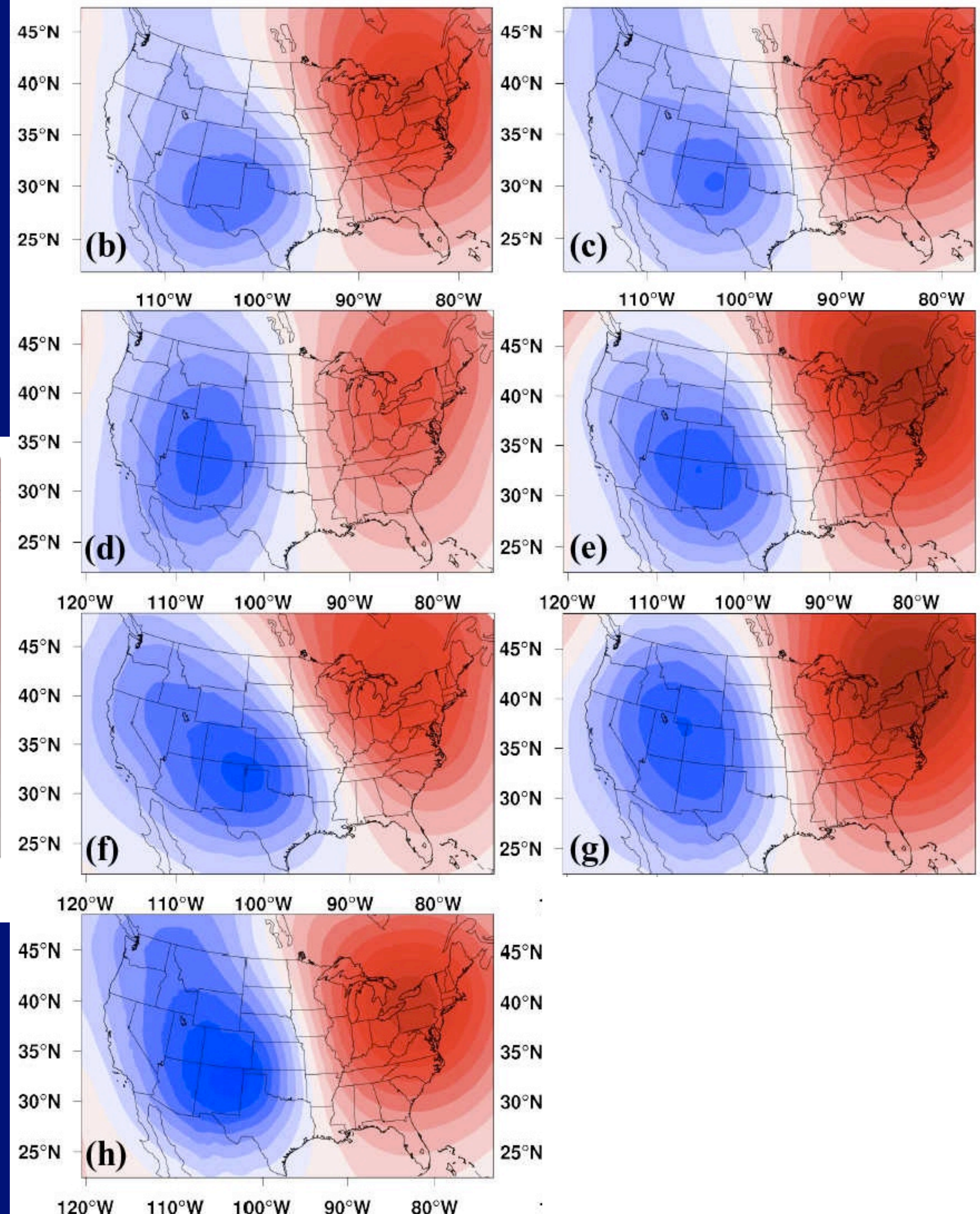
Composite Structure of Extreme Events: NARR
(500 hPa Z & 10-m wind)



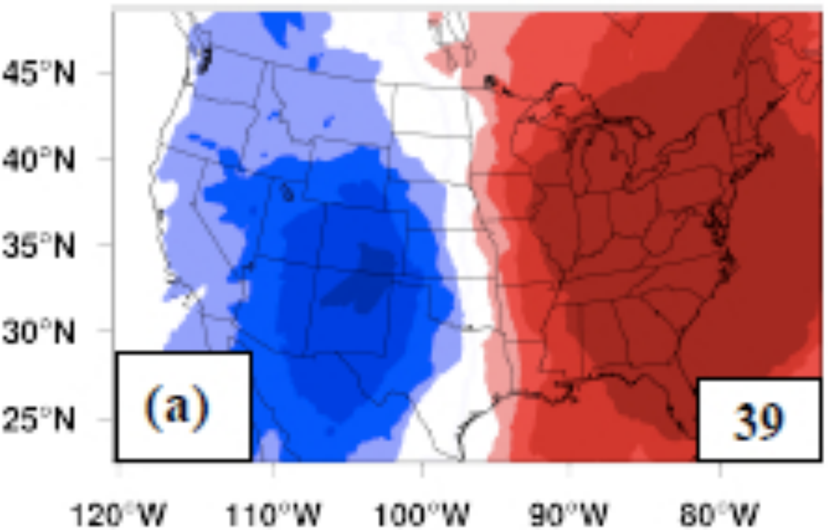
Composite Structure of Extreme Events: 500 hPa Z Anomalies

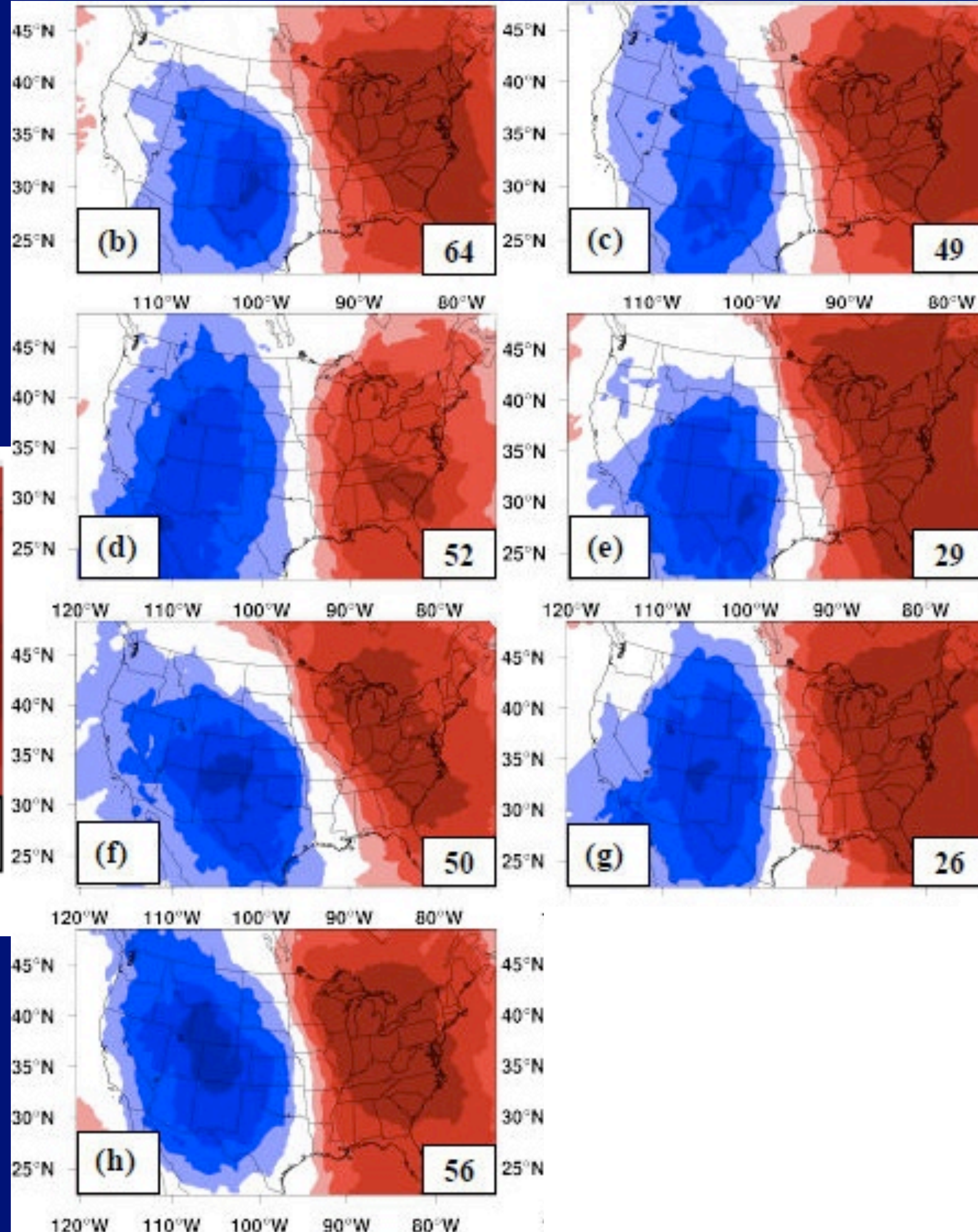


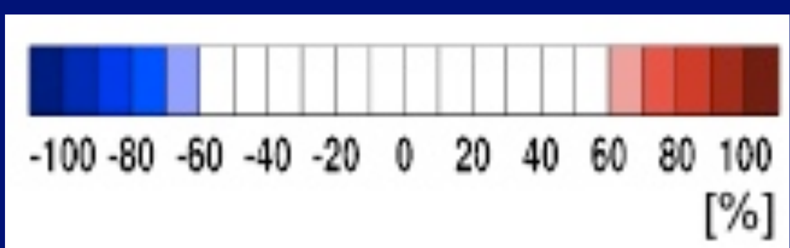




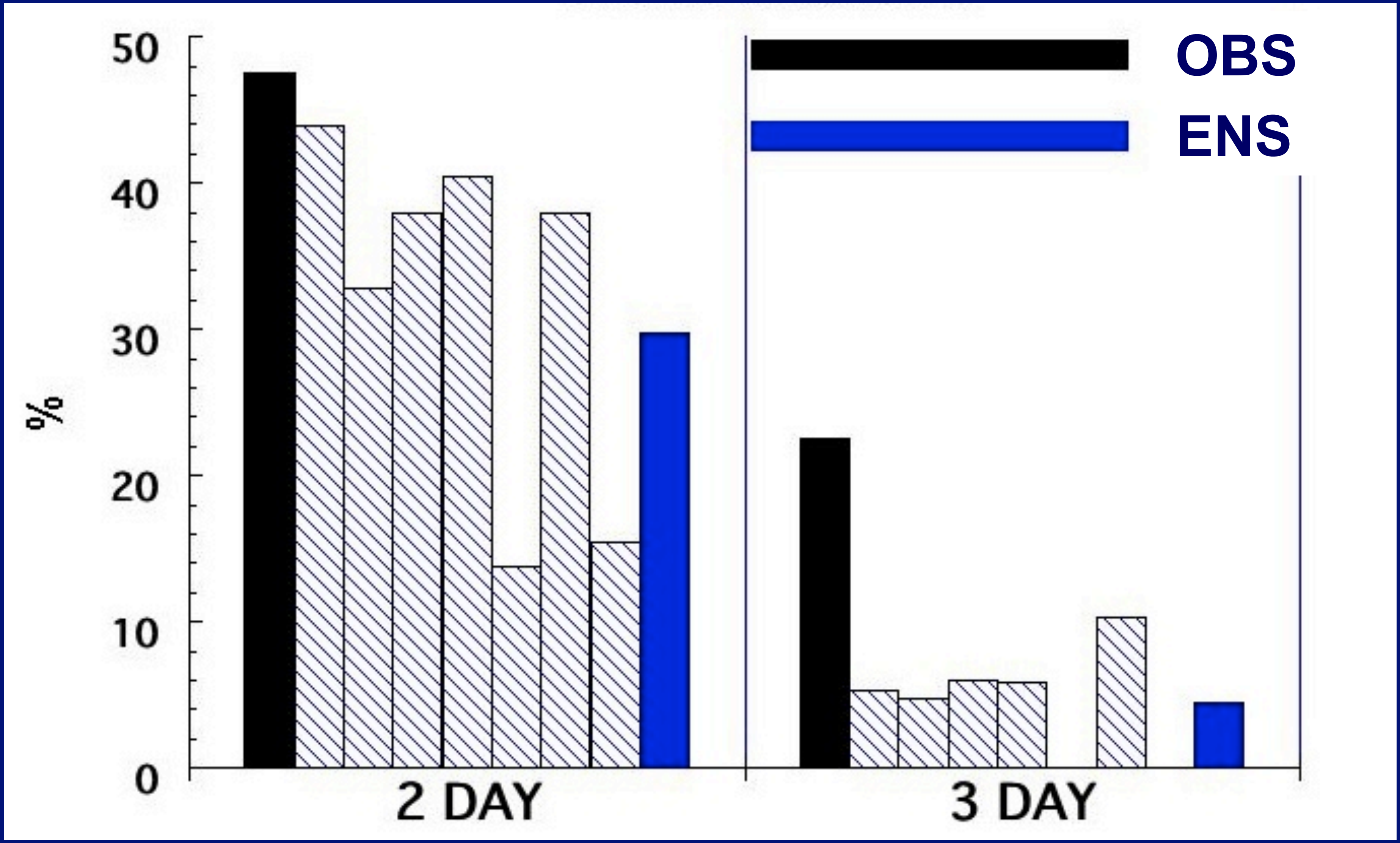
Representativeness of Extreme Events: 500 hPa Z Anomalies



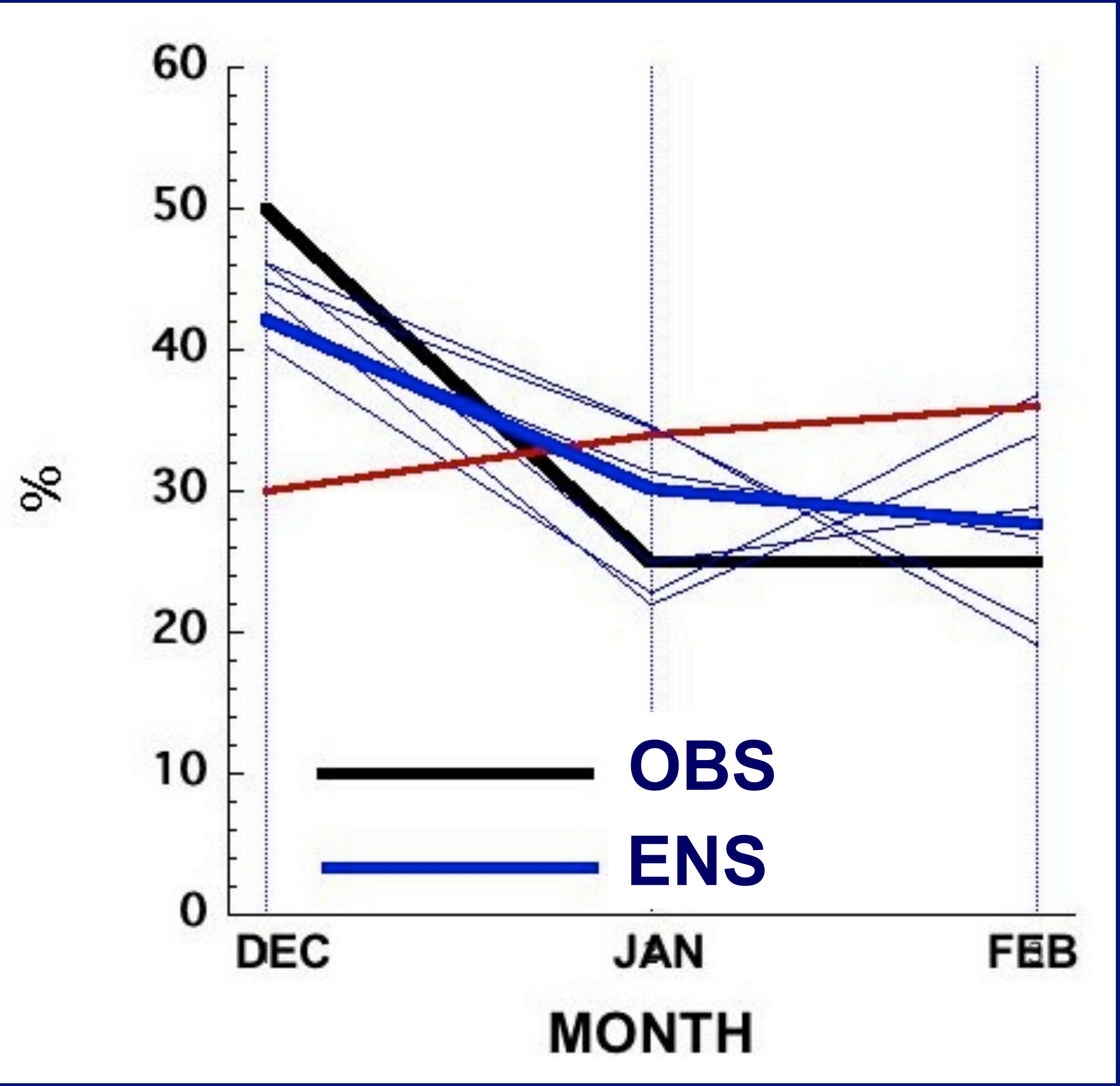




Event Persistence



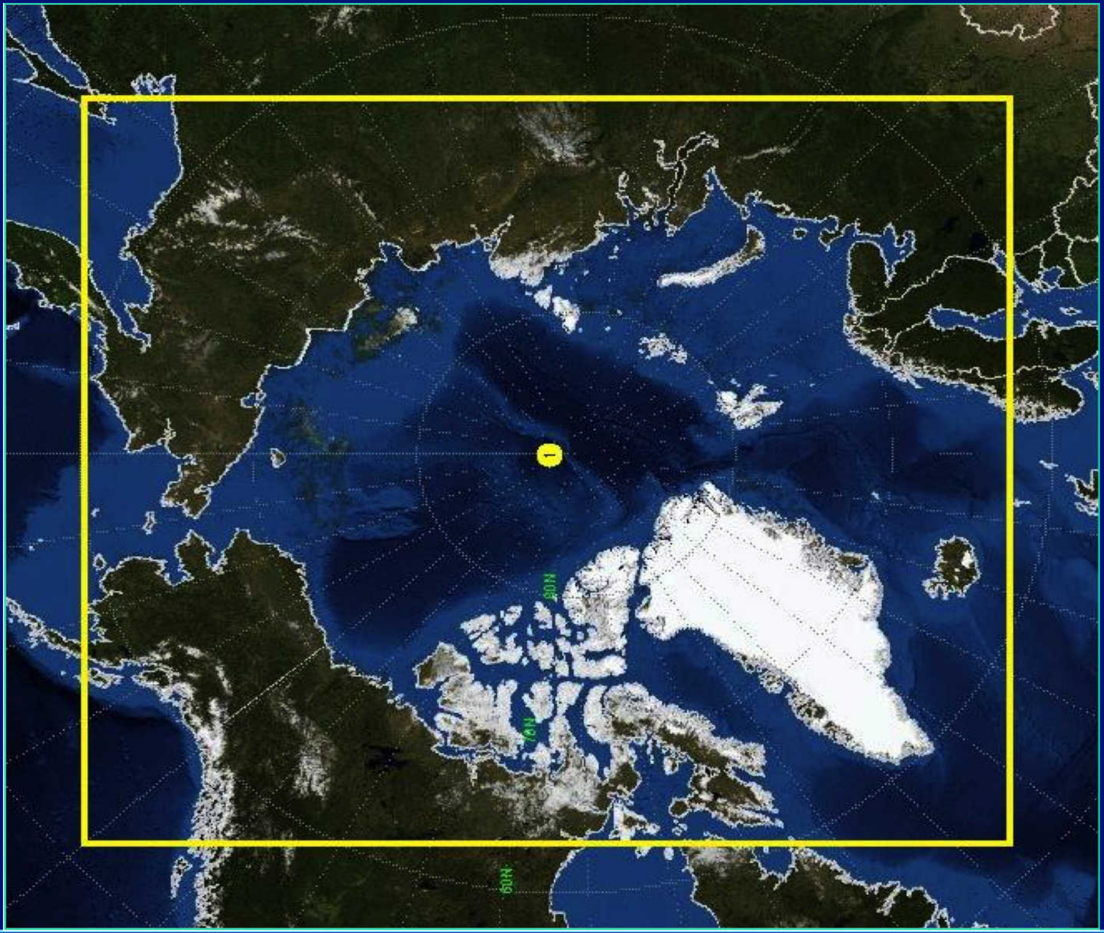
Intraseasonal Variability



Pan-Arctic WRF Simulation

(for WCRP Coordinated Regional Downscaling Experiment)

- **Domain**
  - CORDEX Arctic
- **Resolution**
  ~ 50 km
- **Simulation Period**
  - 1989 - 2007
- **Boundary Conditions**
  - ERA-Interim reanalysis with NSIDC sea ice

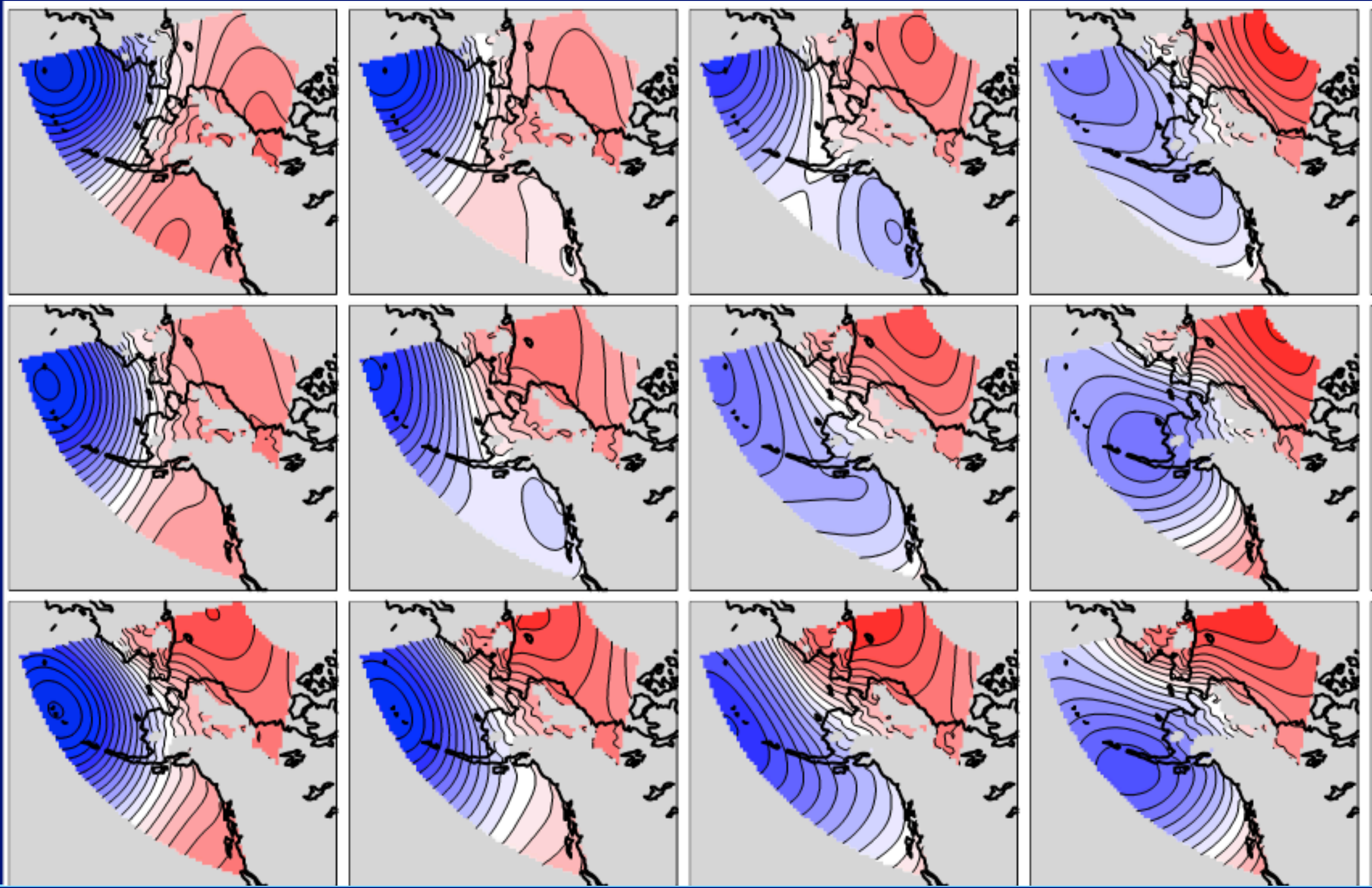


Comparison with observations

- **Observation-based Fields**
  - Precip: NCDC Global Summary of the Day
  - Other fields: ERA-Interim Reanalysis
- **Comparison period: 1992-2007**
  - 1989-1991 omitted for RCM spinup
- **Analysis**
  - "Precipitation event" = Daily precip ≥ 2.5 mm at a grid point
  - Focus on precip intensity ≥ 99%
  - Pool all "events" in the target region

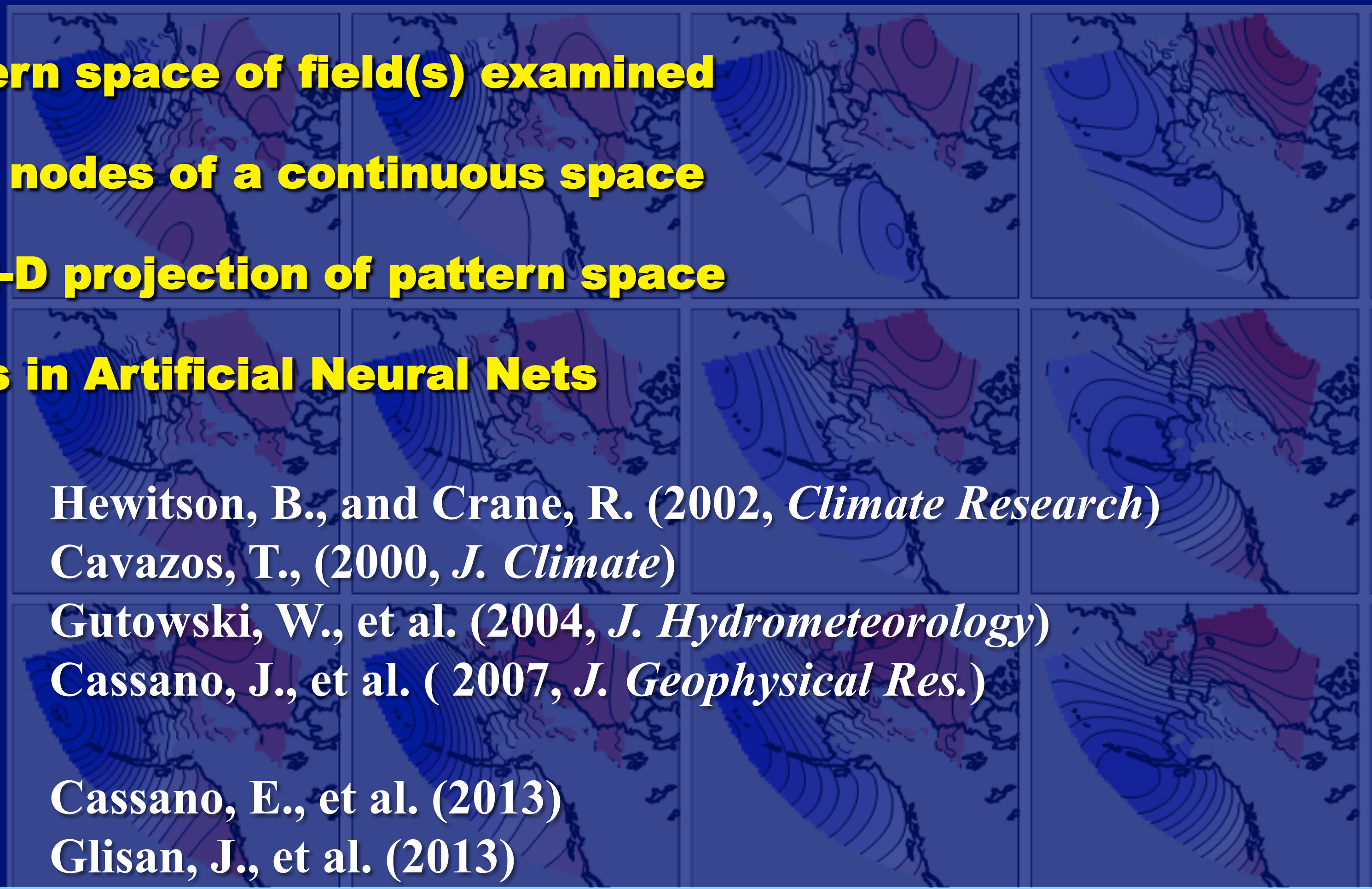
Self-Organizing Maps

Set of maps that …



Self-Organizing Maps

Set of maps that



- **Span pattern space of field(s) examined**
- **Represent nodes of a continuous space**
- **Can give 2-D projection of pattern space**
- **Have basis in Artificial Neural Nets**

Overview: Hewitson, B., and Crane, R. (2002, *Climate Research*)

Examples: Cavazos, T., (2000, *J. Climate*)
Gutowski, W., et al. (2004, *J. Hydrometeorology*)
Cassano, J., et al. (2007, *J. Geophysical Res.*)

Posters: Cassano, E., et al. (2013)
Glisan, J., et al. (2013)

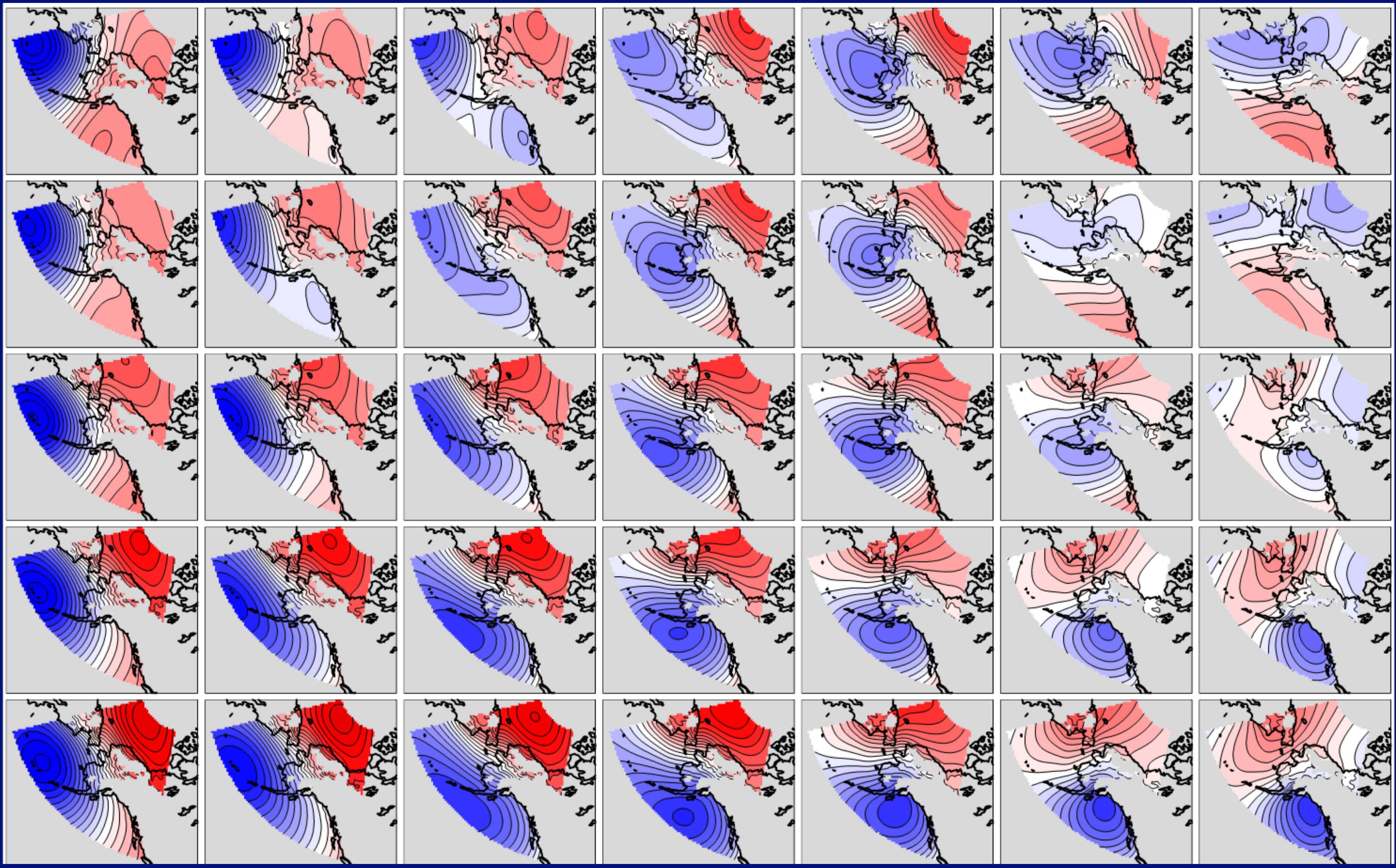
Self-Organizing Maps

Relation to EOFs, etc?

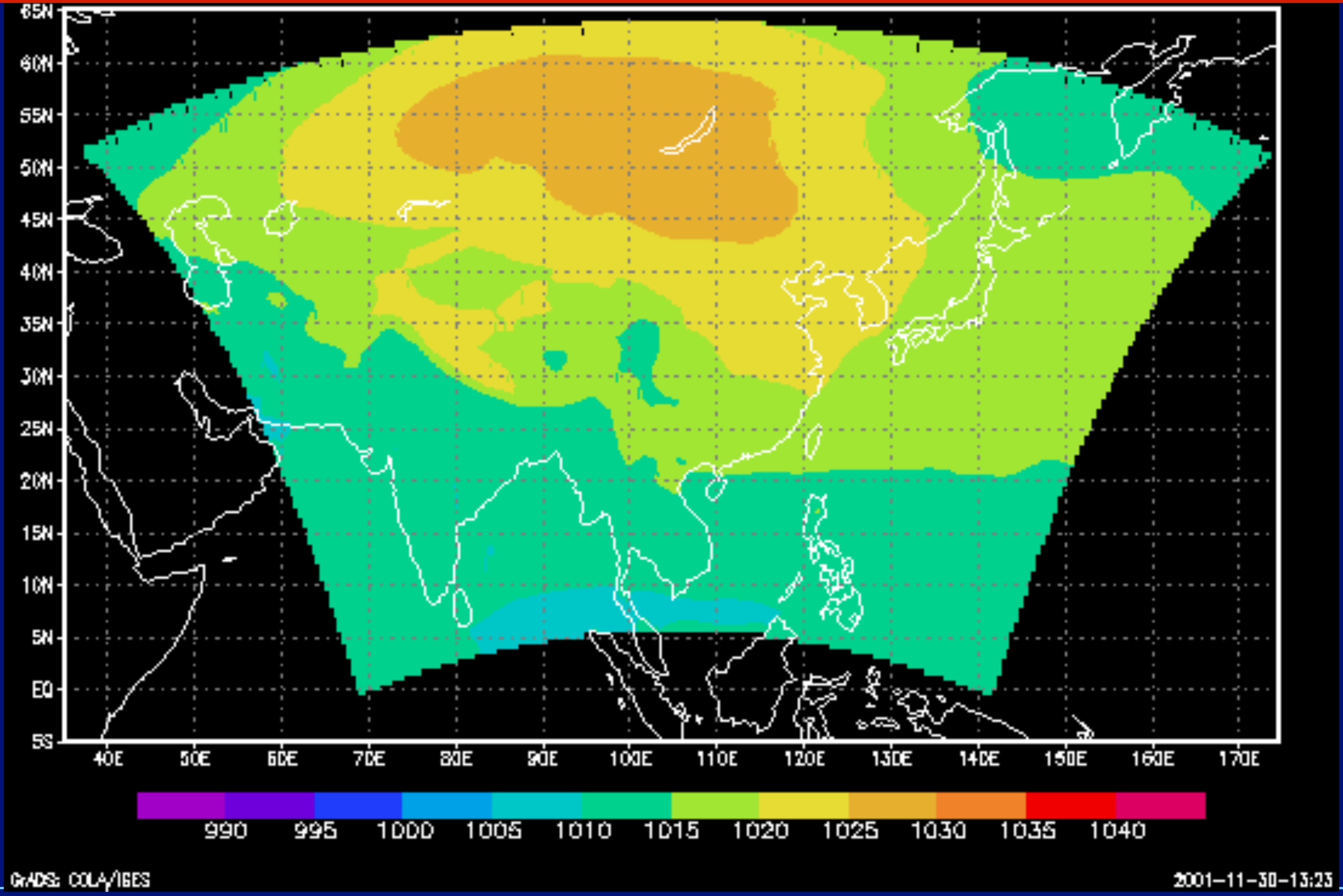
SOMs ...

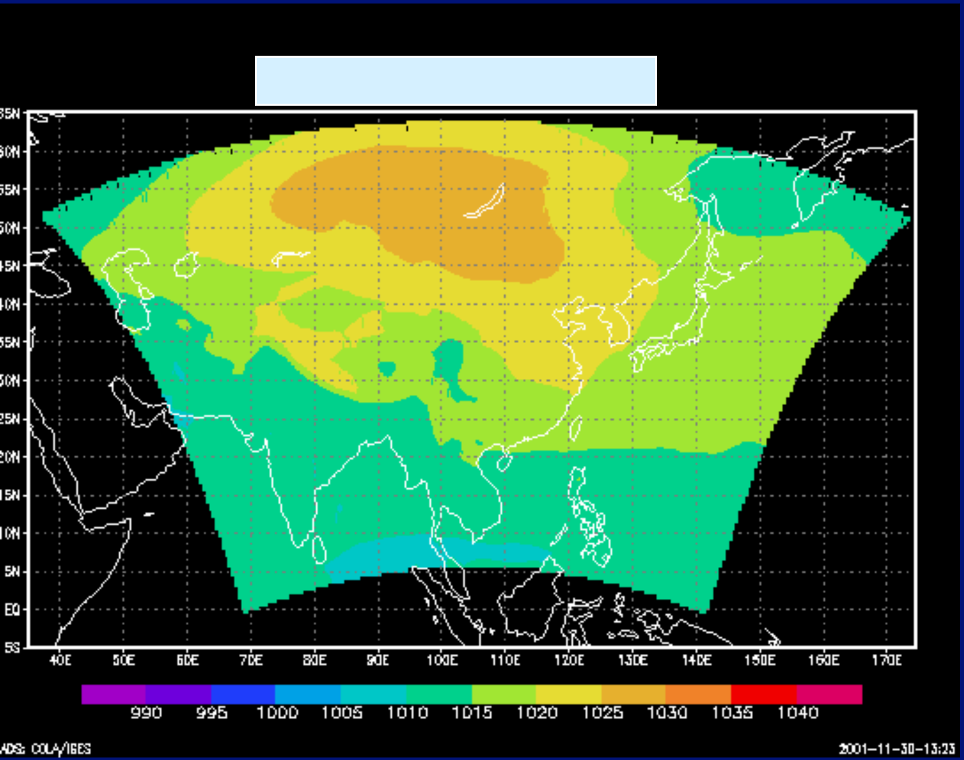
- minimize RMS{input - output}
- favor high variance behavior
- ~ Σ (rotated EOF)

SOM set: Sea-level pressure



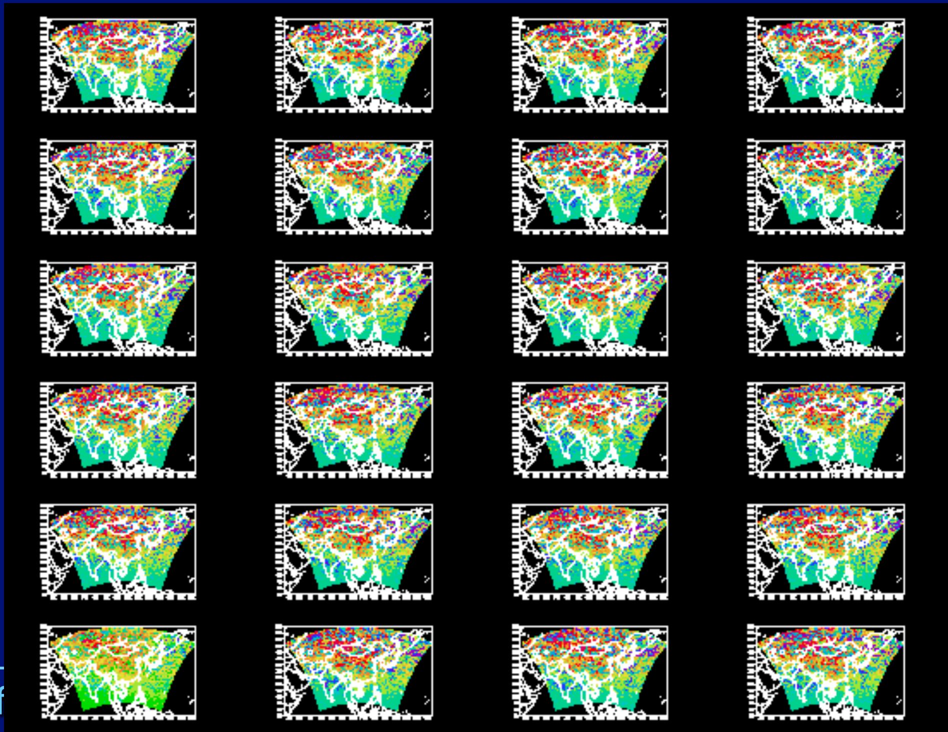
Training: Apply input sequence of maps Example

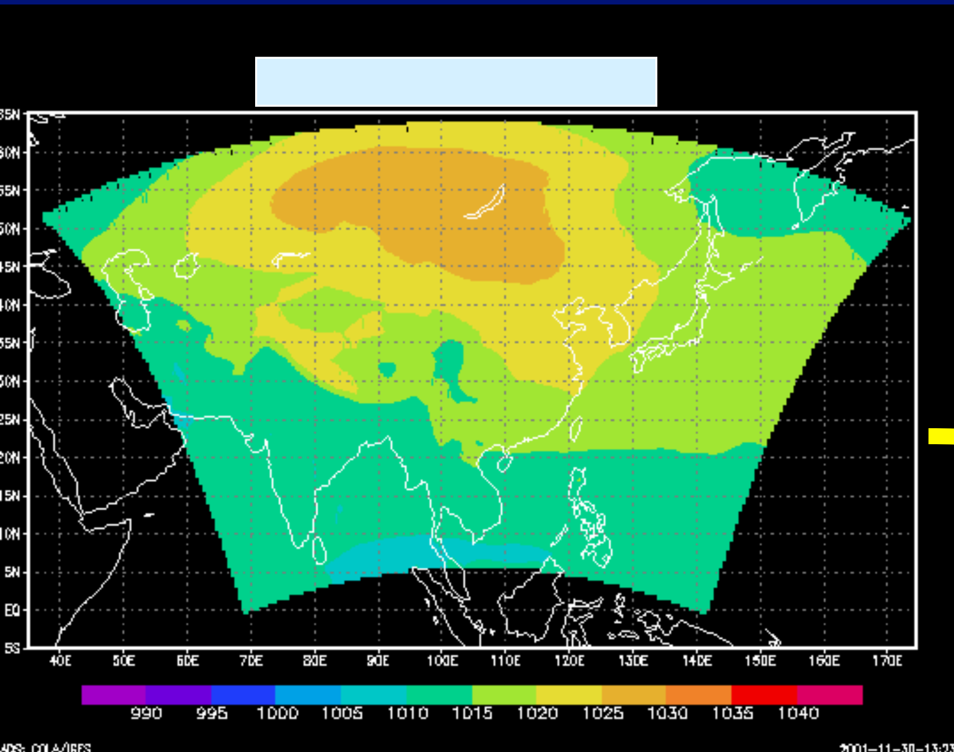




Compare sample to ...

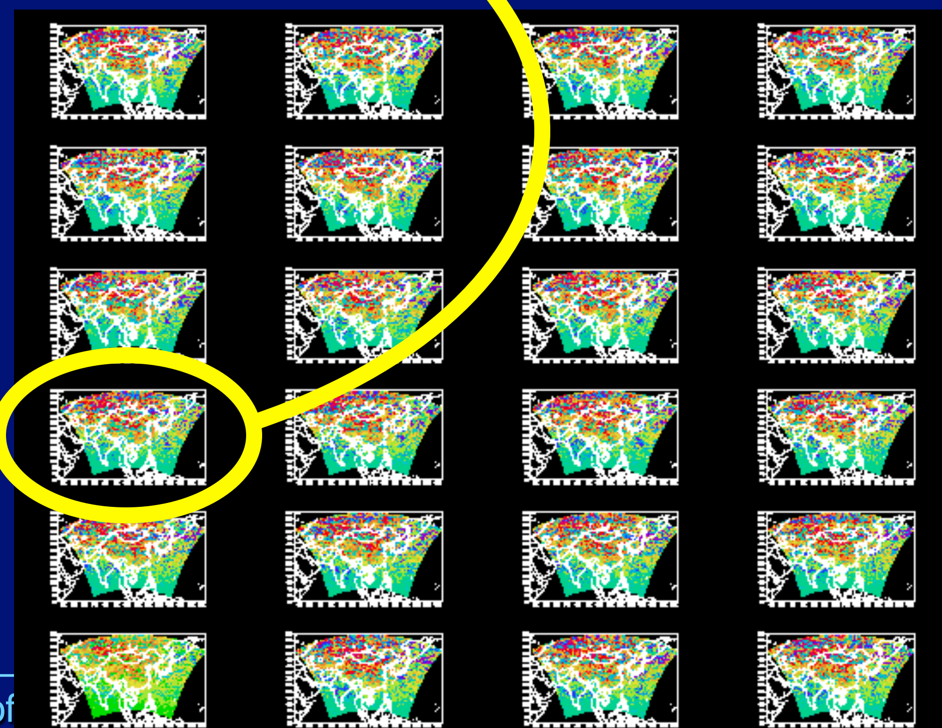
... existing set



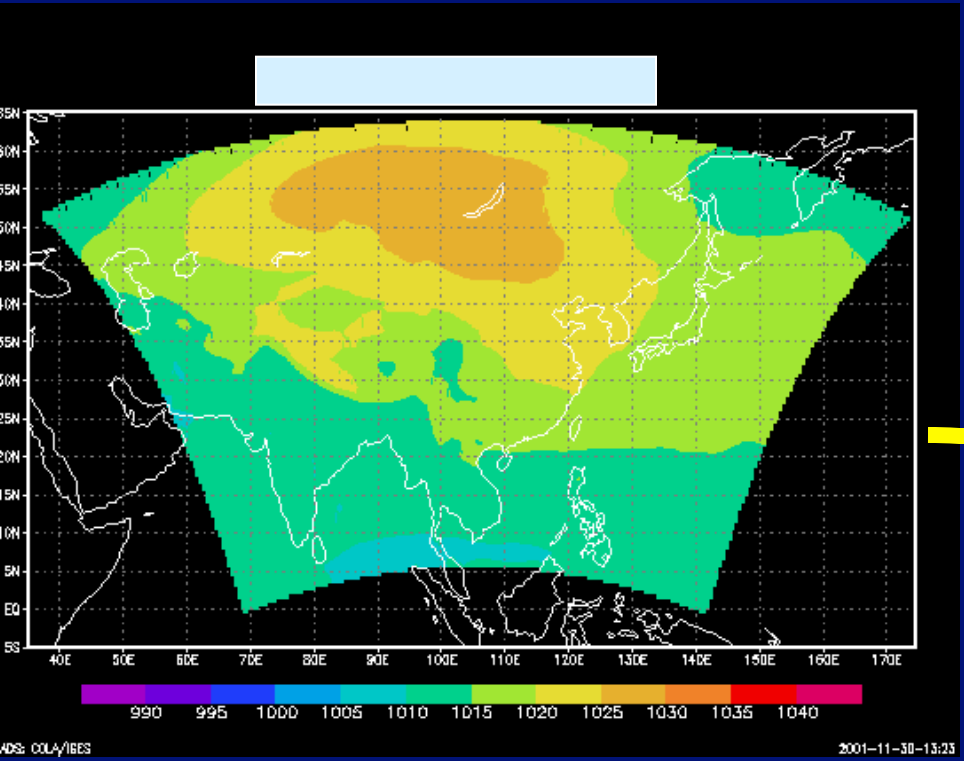


Find closest map ...

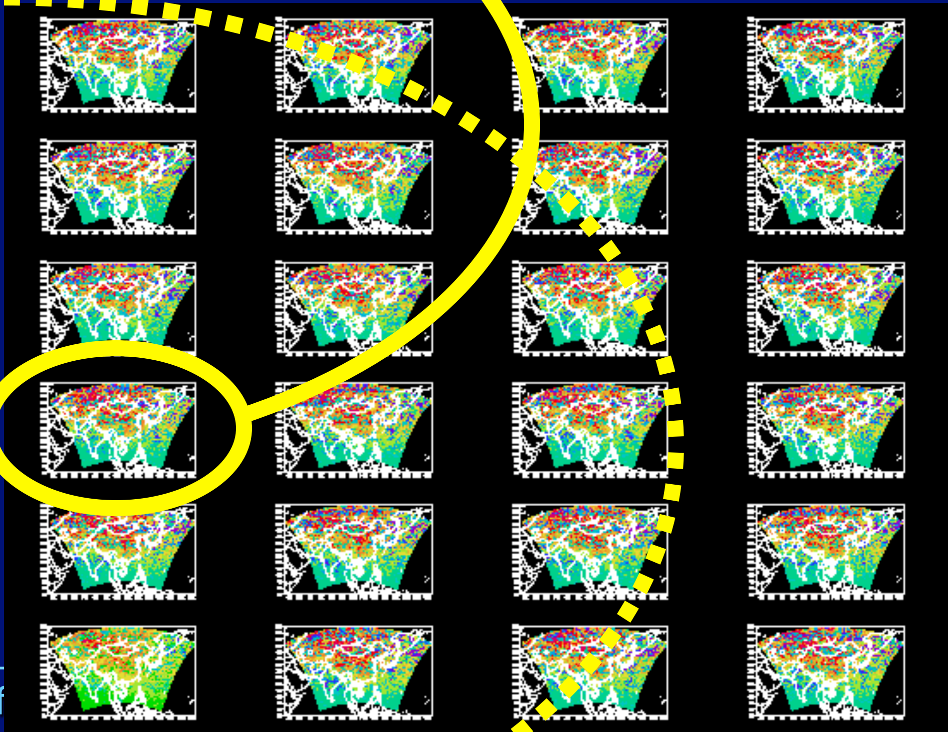
(here - smallest RMS difference)

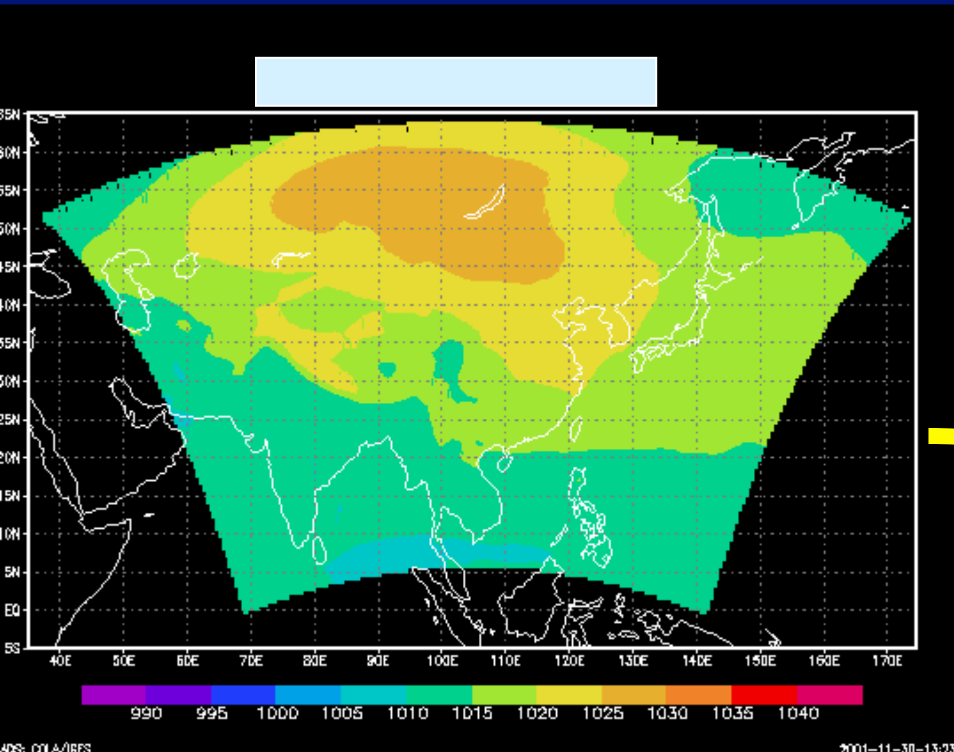


... and nudge it toward sample



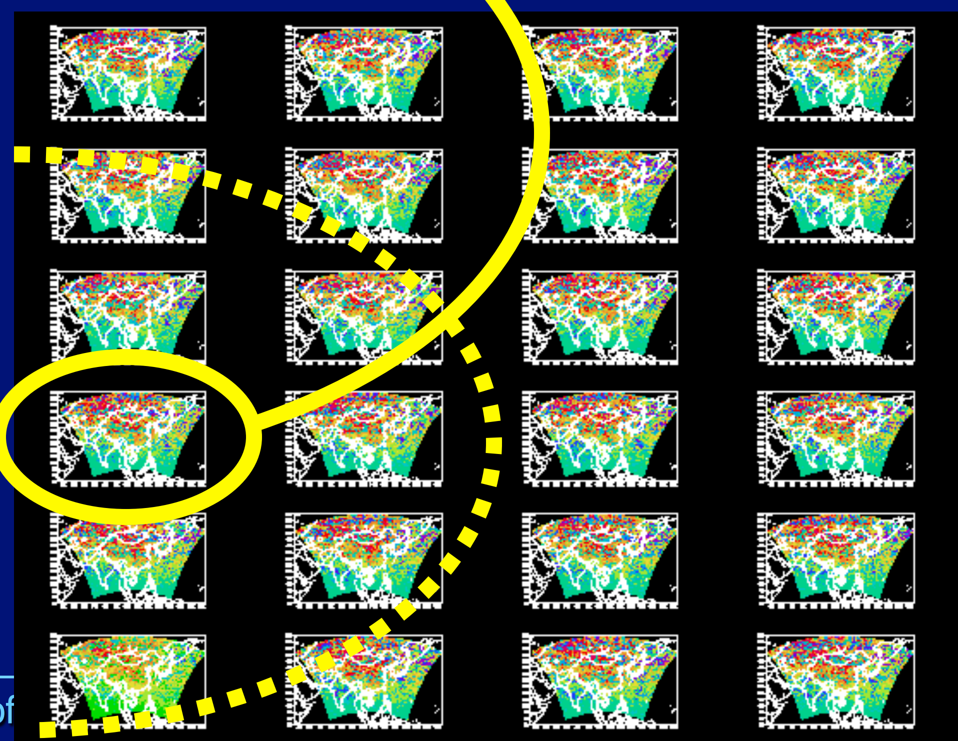
Nudge also a surrounding region ...

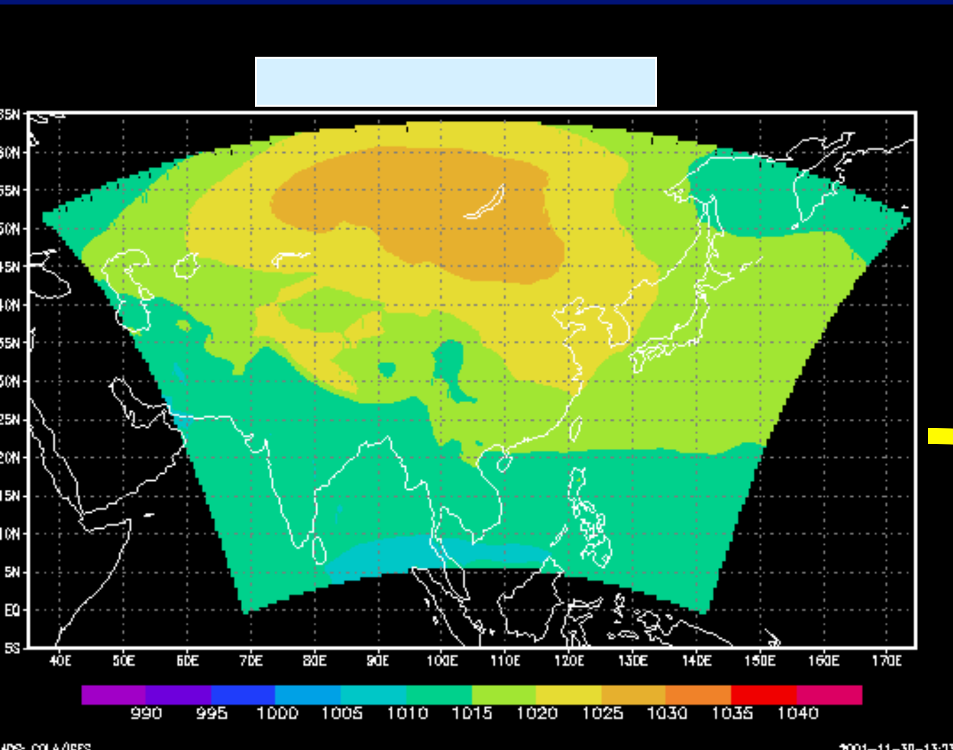




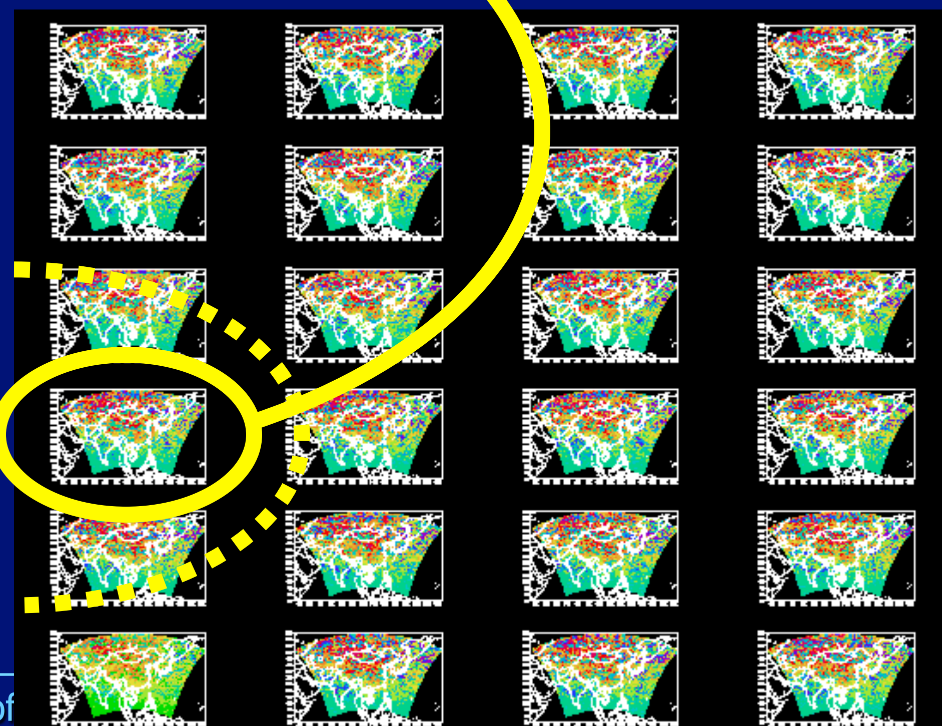
Nudge also a surrounding region ...

... that decreases with iteration



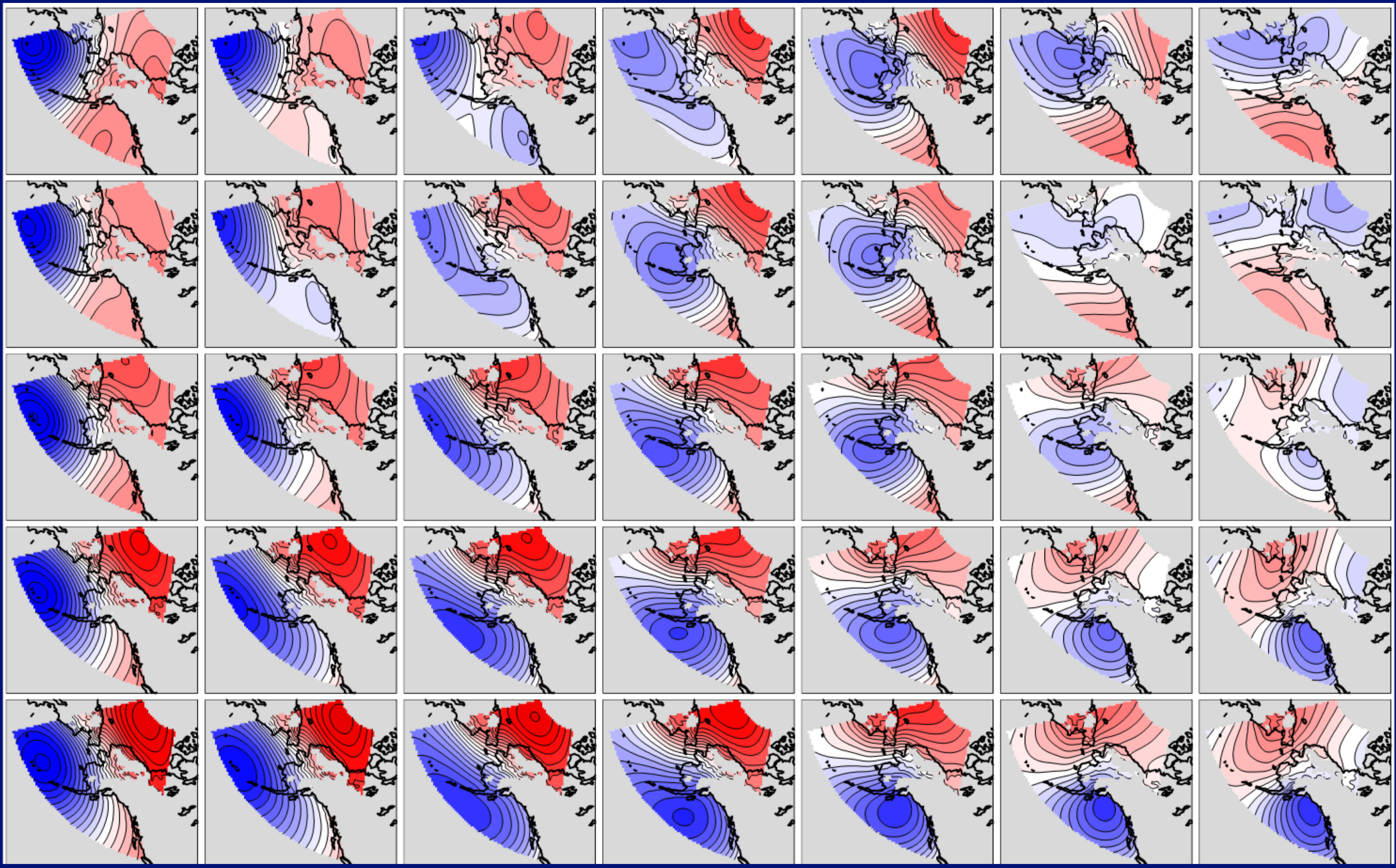


Nudge also a surrounding region ...



... that decreases with iteration

SOM set: Sea-level pressure



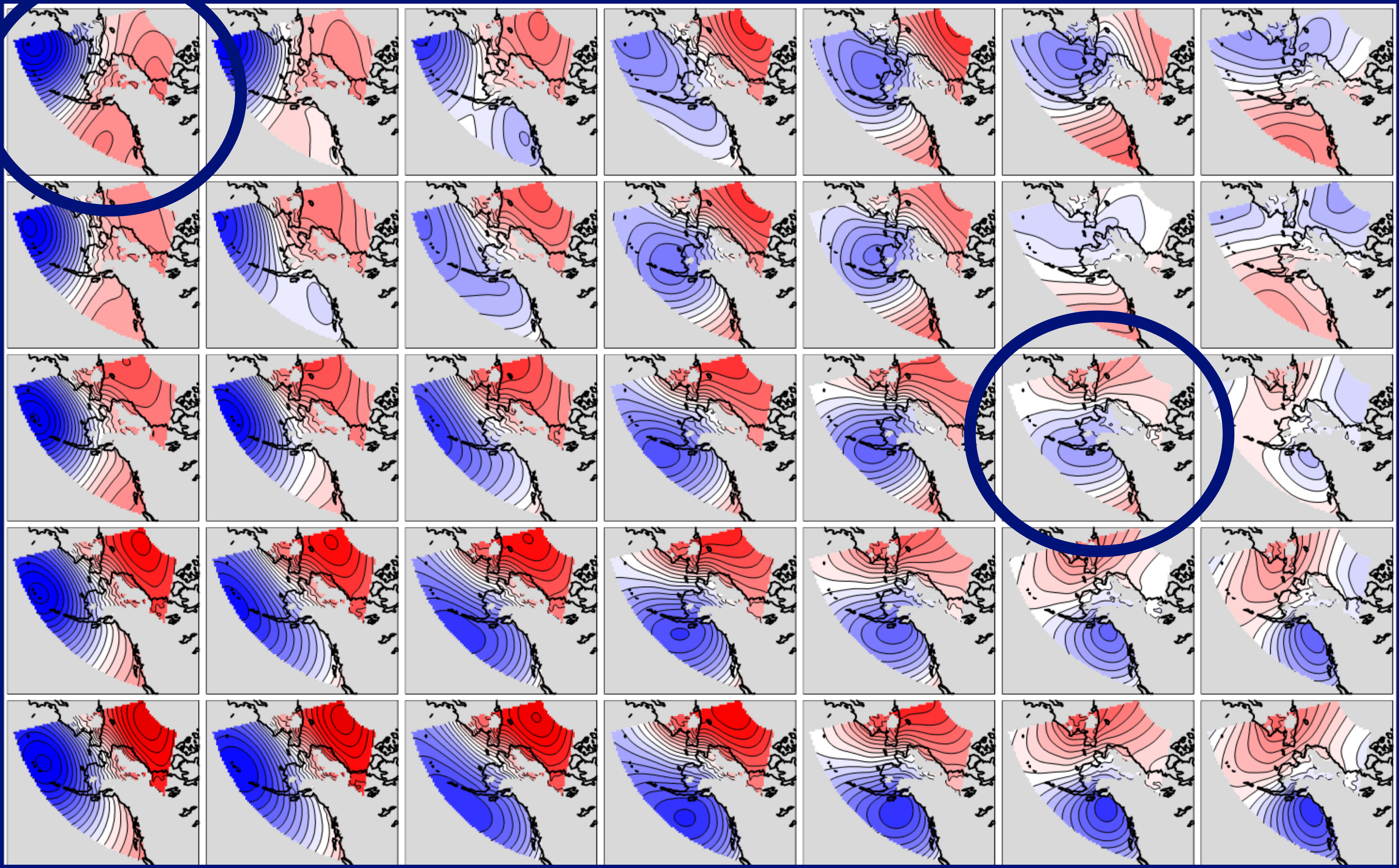
Frequency Distribution in SOM Space: WRF Climatology

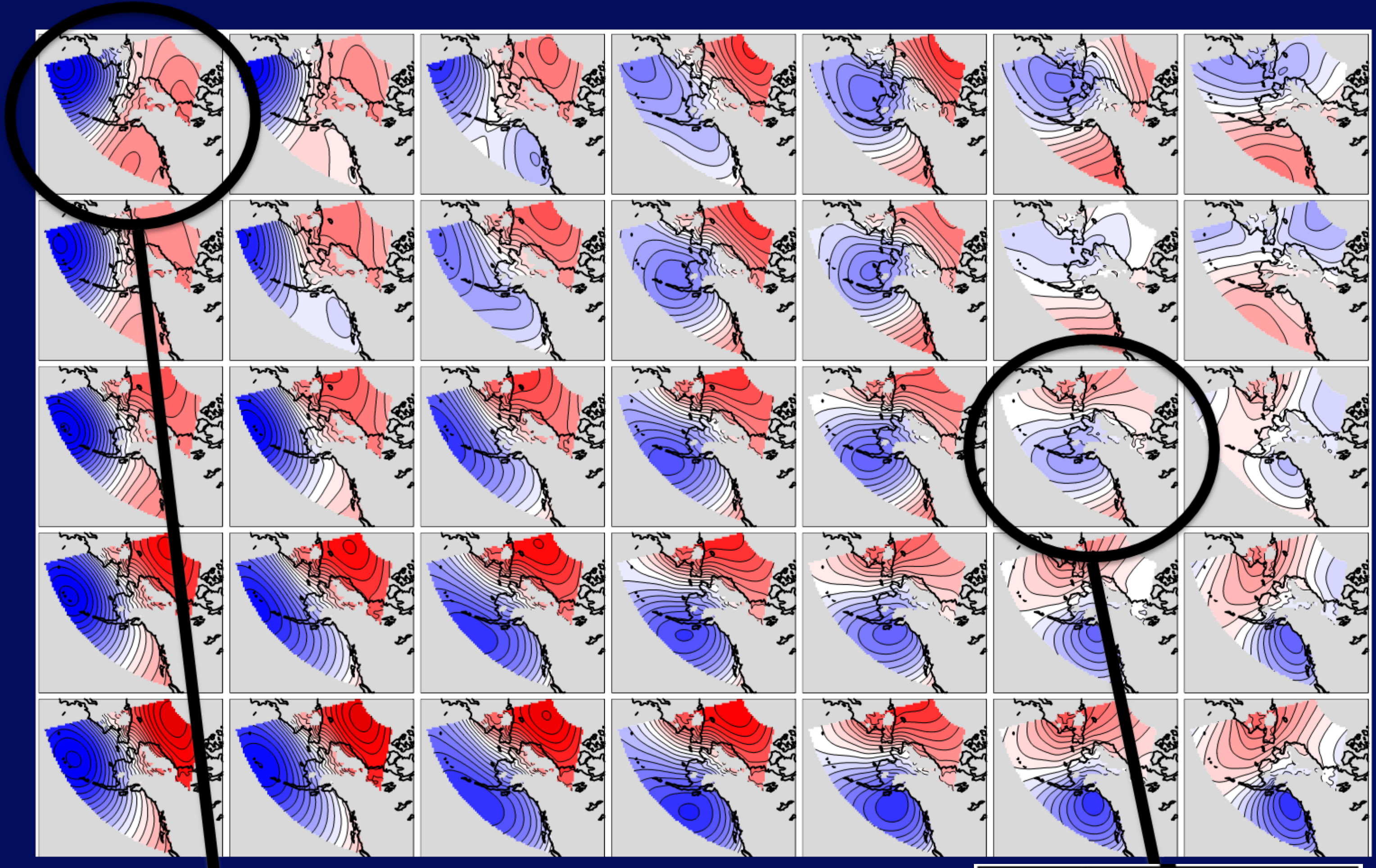
	1	2	3	4	5	6	7
1	4.84%	1.98%	3.79%	3.56%	3.38%	3.85%	2.98%
2	2.45%	2.04%	1.69%	3.38%	2.51%	2.10%	3.85%
3	2.74%	1.98%	2.86%	2.22%	2.22%	3.44%	3.21%
4	2.33%	2.10%	1.63%	2.16%	2.51%	2.33%	2.45%
5	5.08%	2.63%	3.68%	4.20%	2.04%	2.33%	3.44%

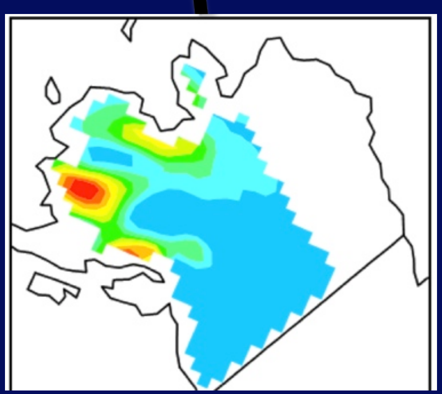
Frequency Distribution in SOM Space: WRF Extreme Precipitation

	1	2	3	4	5	6	7
1	5.56%	0.00%	0.00%	0.00%	4.44%	12.22%	3.33%
2	0.00%	0.00%	0.00%	7.78%	17.78%	3.33%	0.00%
3	5.56%	1.11%	0.00%	6.67%	5.56%	4.44%	1.11%
4	2.22%	0.00%	0.00%	1.11%	2.22%	0.00%	0.00%
5	12.22%	1.11%	2.22%	0.00%	0.00%	0.00%	0.00%

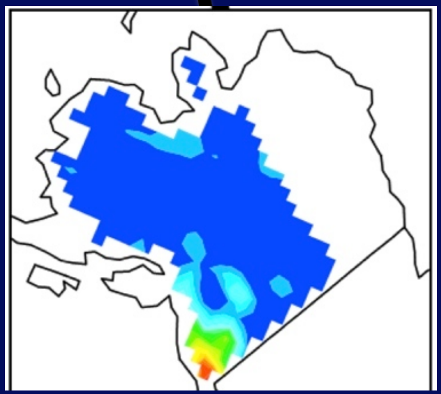
SOM Space: Example Cases



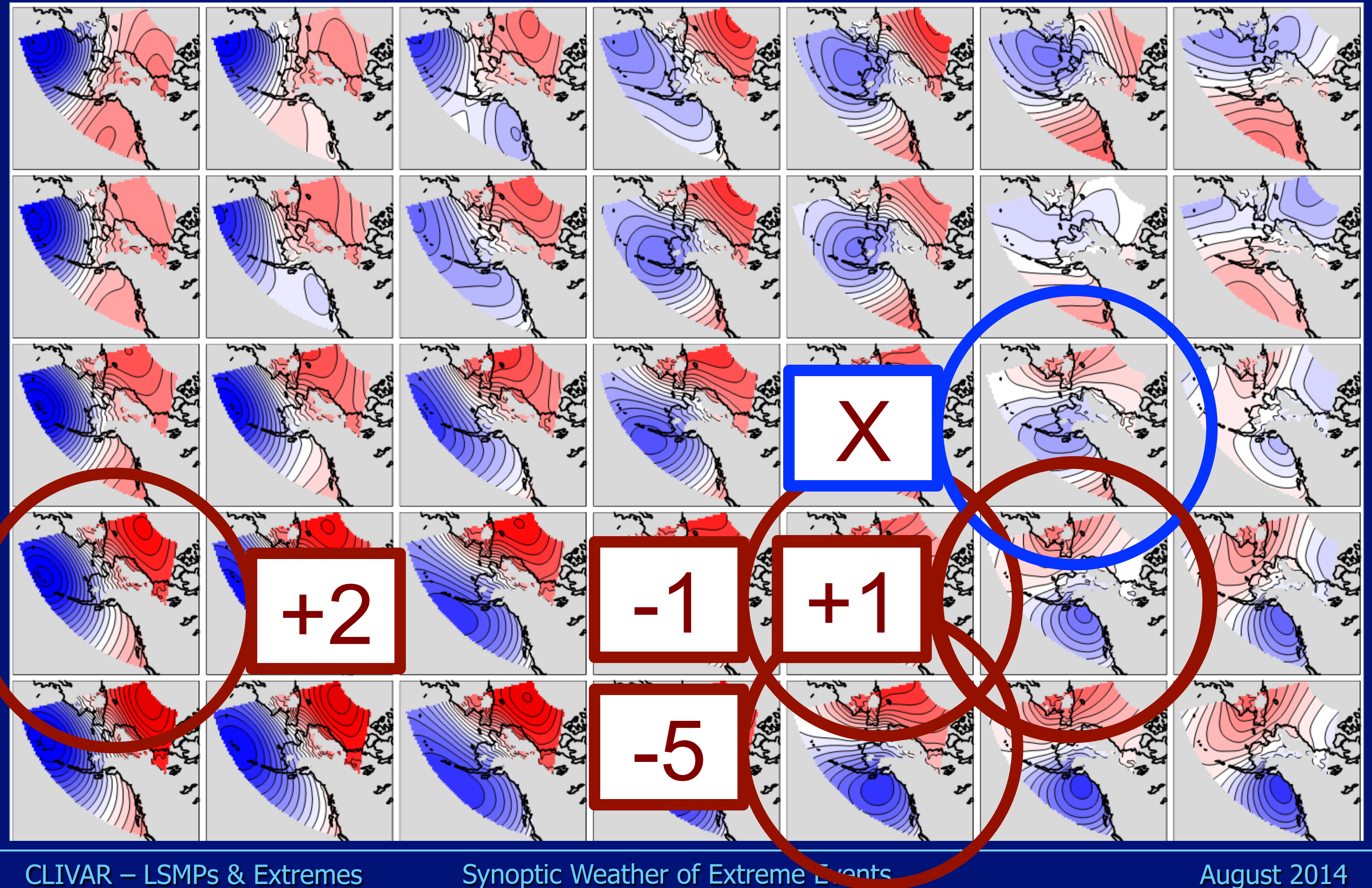




SOM Space: Example Cases



SOM Space: Time Evolution



SUMMARY

- **For fairly simple (repeated) extreme events:**
  - Straightforward compositing yields physical insight
  - Simple measures representativeness useful

- **For more general, complex mixes of extreme events:**
  - SOMs - objective discrimination of event types
  - Identify “common” and less frequent types

- **SOMs can also yield**
  - insight into temporal evolution
  - distinction between extreme and non-extreme events with similar circulation/environment
  - statistical significance of differences in data sources

Thank You!