On the connection between low-frequency modulation of large-scale weather regimes and springtime extreme flooding over the Midwest of the United States

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36th Annual Climate Diagnostics and Prediction Workshop, Fort Wort, TX, Oct. 3–6, 2011

Outline

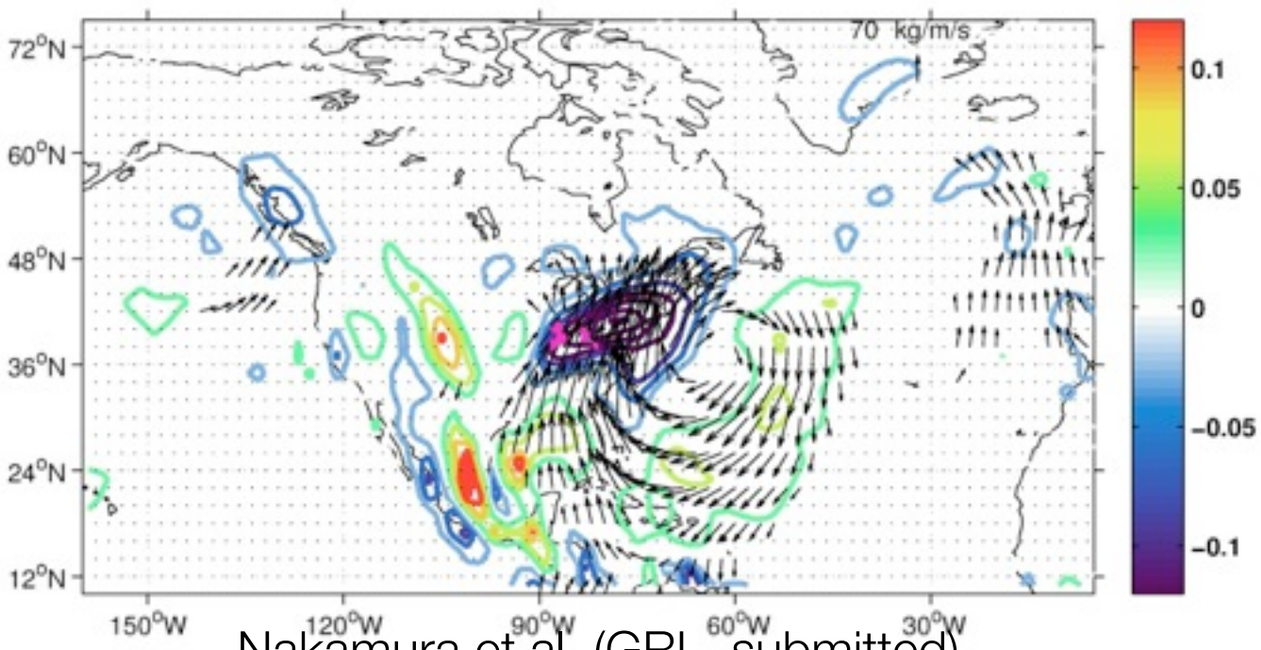
- Analysis of daily circulation types and rainfall states for the March–May season, over the Midwest US

- Connection between weather types and basin-scale 10-year flood events

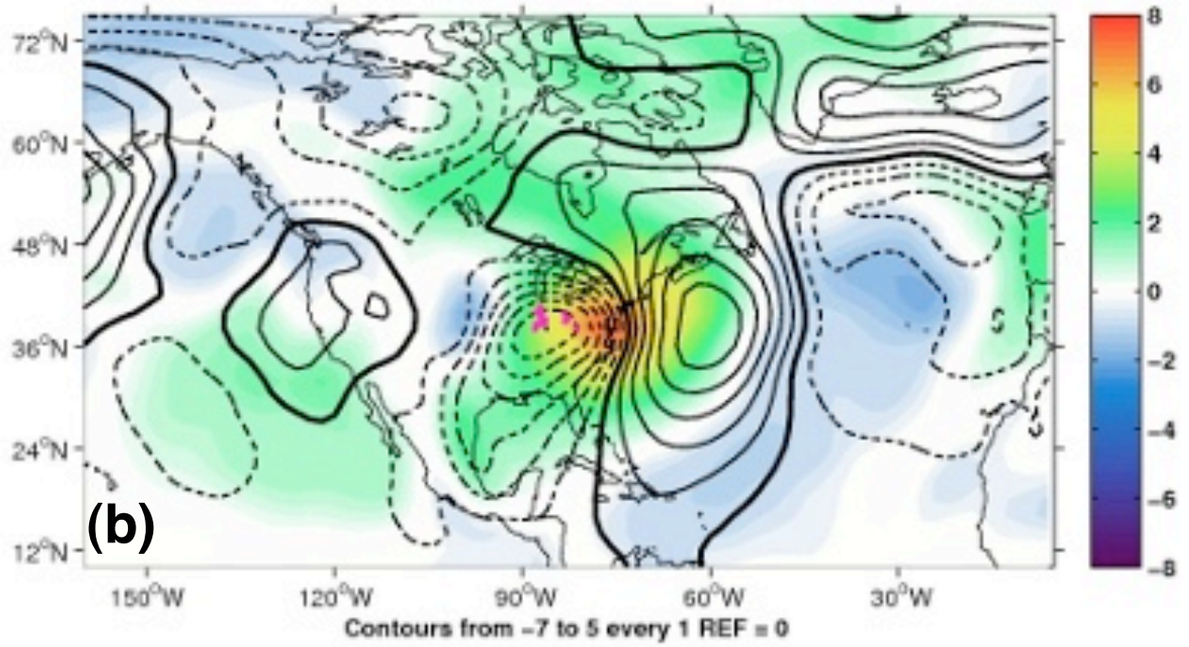
- Connection between weather types and low-frequency modes: any potential predictability?

Composite anomalies 1-day prior to 20 extreme flooding events in the 20th Century

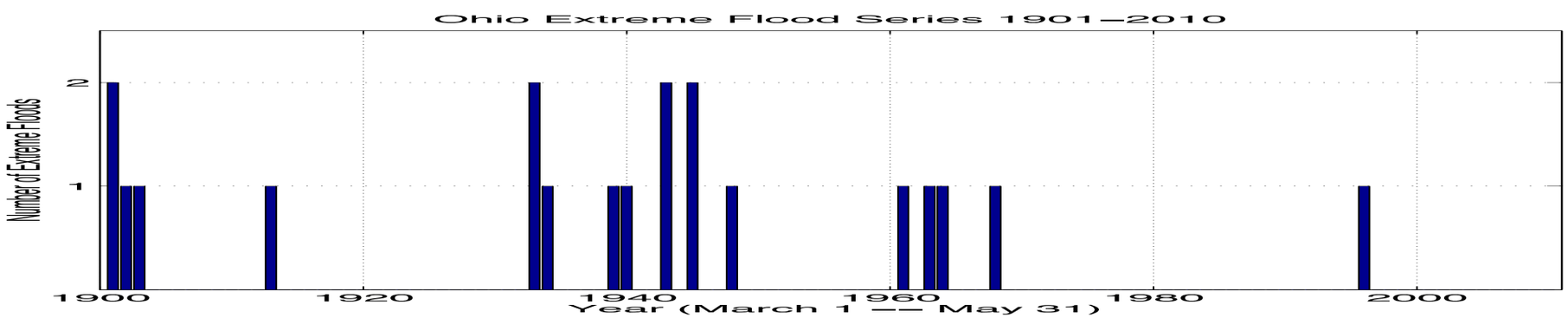
1000–600mb Moisture Flux & Divergence



SLP & 850mb Temperature

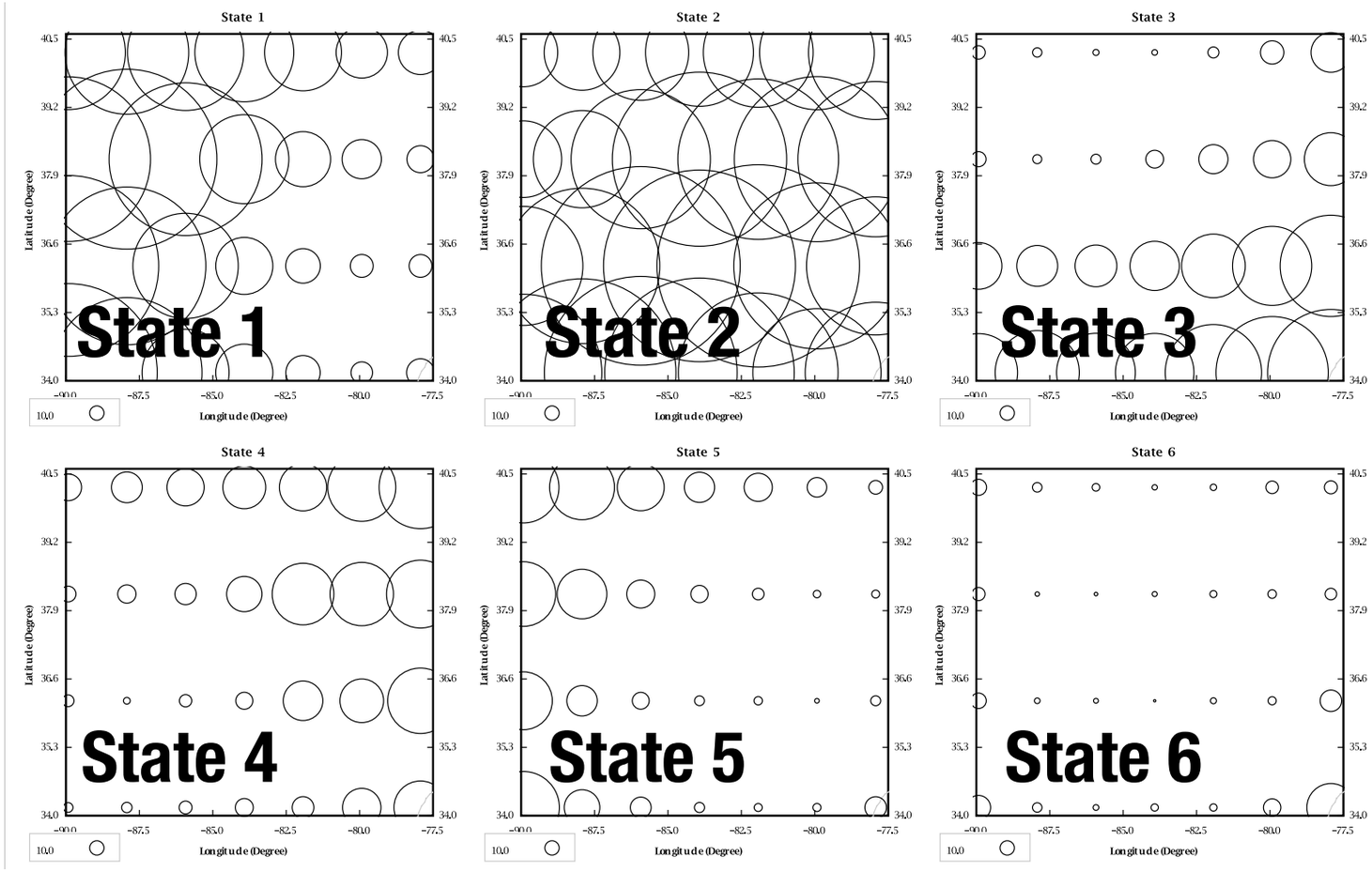


Nakamura et al. (GRL, submitted)



Hidden Markov Model fit to CPC Unified Precip, MAM 1979-2005, [88W-84W, 36-40N]

Rainfall Amounts, by State



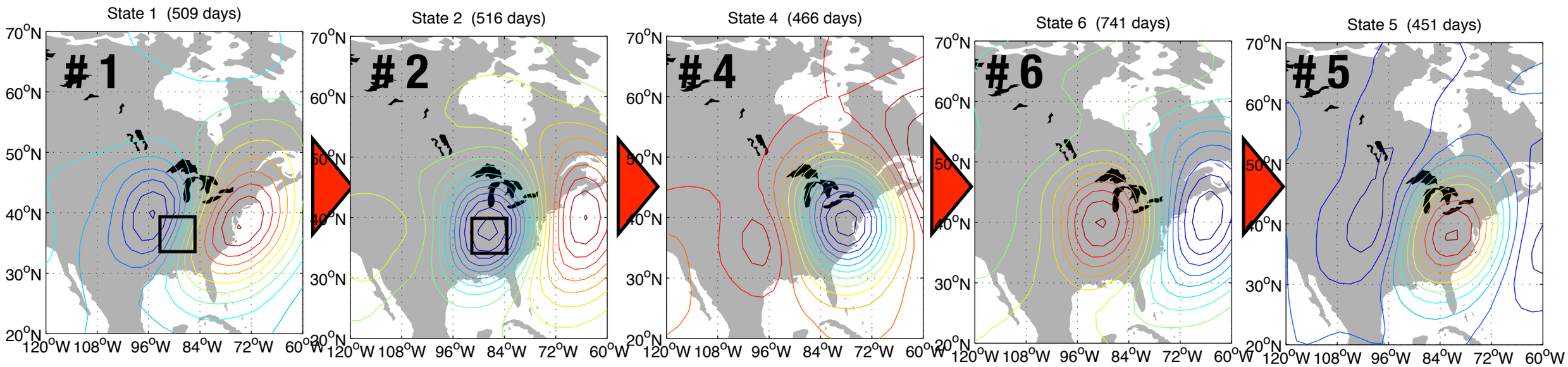
Transition probabilities

to state ...

from state ...	*1*	*2*	*3*	*4*	*5*	*6*
1	**27**	48	12	10	2	1
2	5	**33**	16	35	2	9
3	11	11	**33**	6	13	26
4	10	3	7	**30**	15	34
5	49	11	5	10	**20**	5
6	6	1	4	4	30	**56**

cycle: 1->2->4->6->5->1

Composites of 700mb geopotential anomalies for each HMM rainfall state



WET STATE

T~7 days

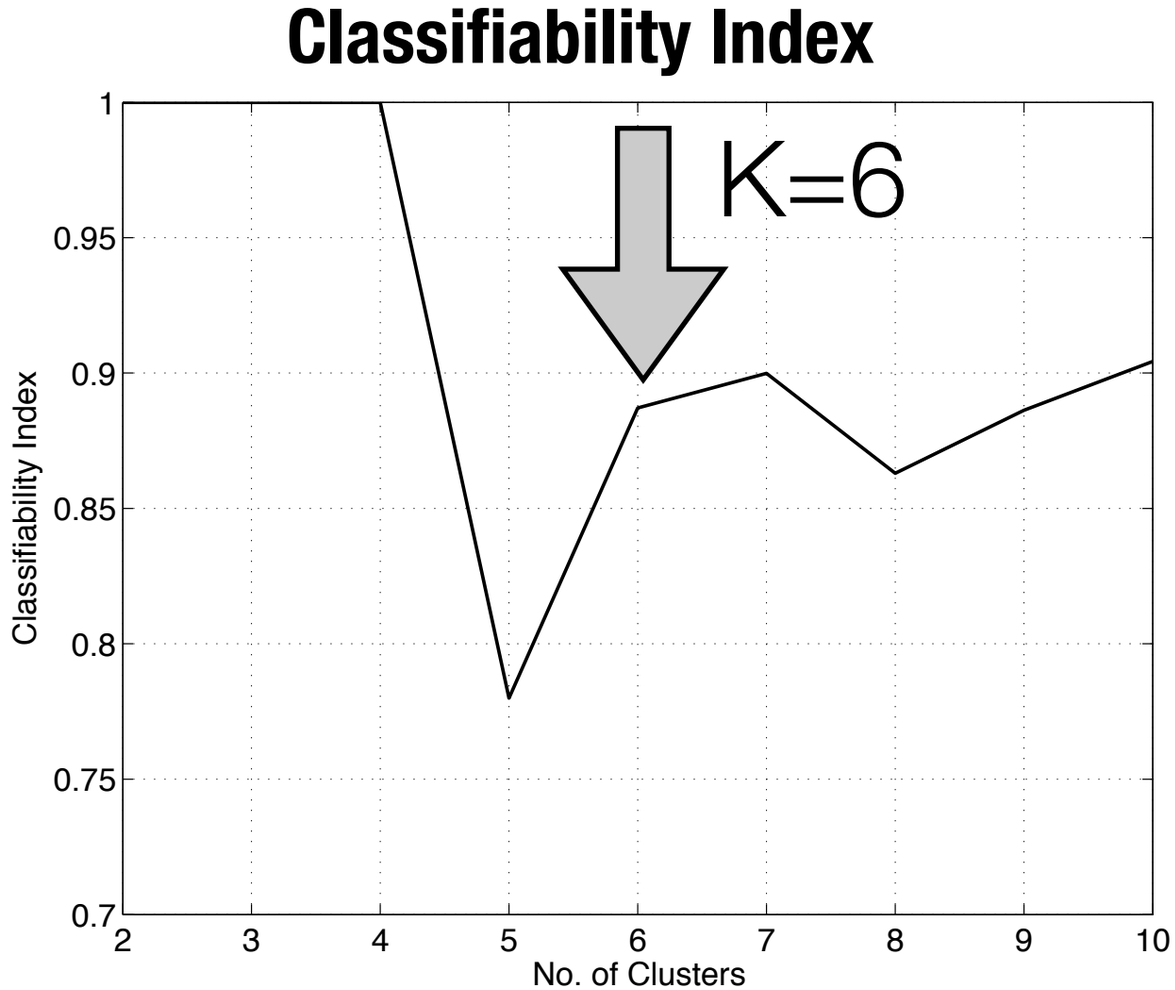
C.I. = 20 gpm

A broader perspective: Cluster analysis of 700-mb geopotential height fields

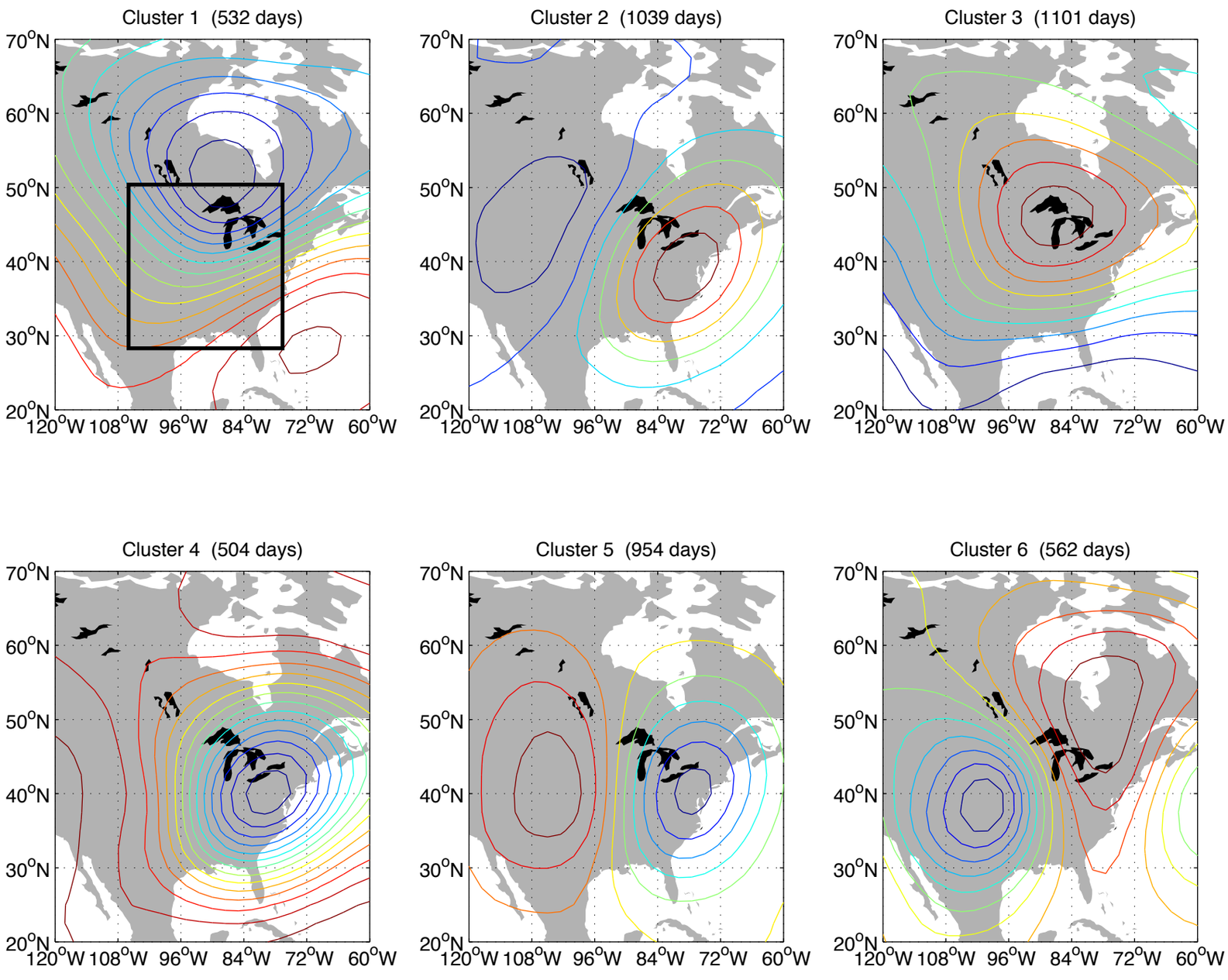
- NNRP1 700-mb geopotential height fields [30-50N, 105W-75W]

- March–May season, 1961–2011

- K-means analysis

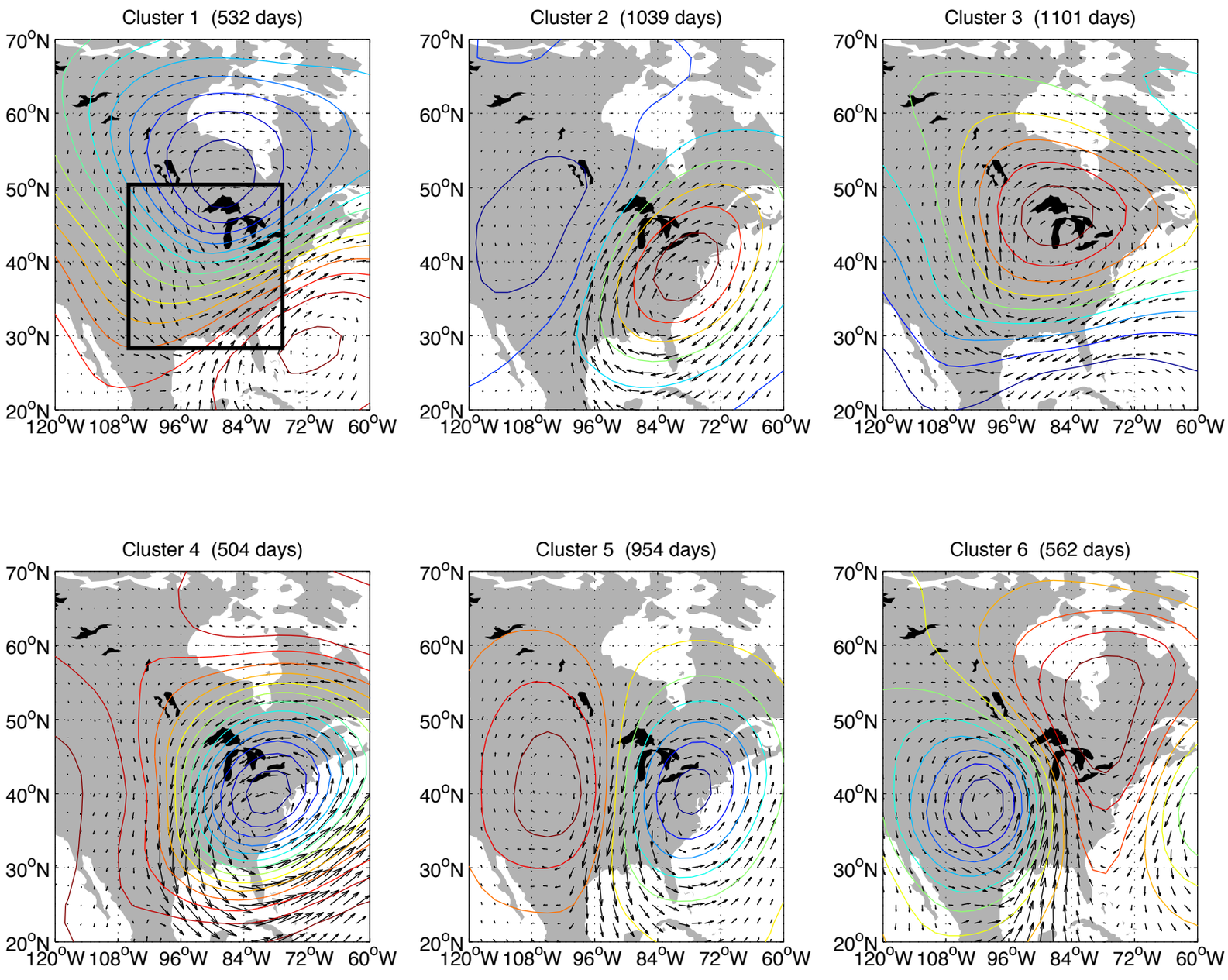


Six-cluster solution:
700mb Geopotential Height Anomalies



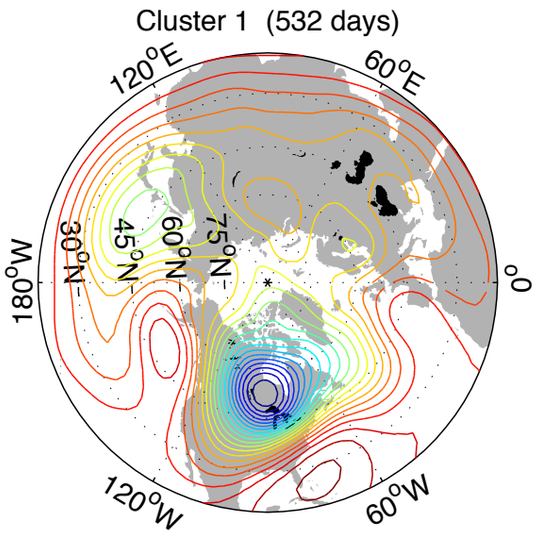
C.I. = 20 gpm

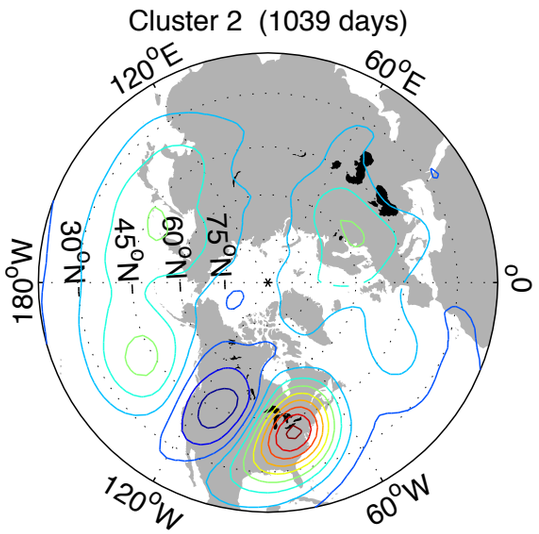
With vertically-integrated moisture flux anomaly composites superimposed

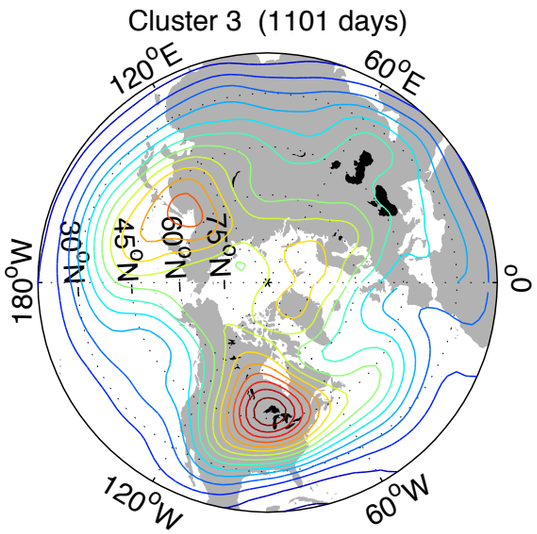


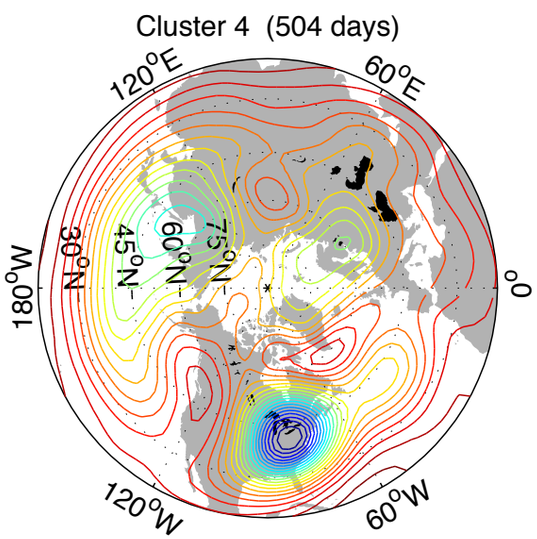
C.I. = 20 gpm

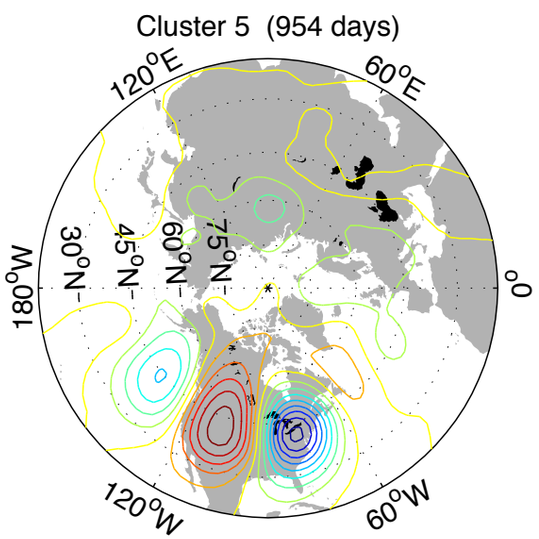
Z-500 anomaly composites

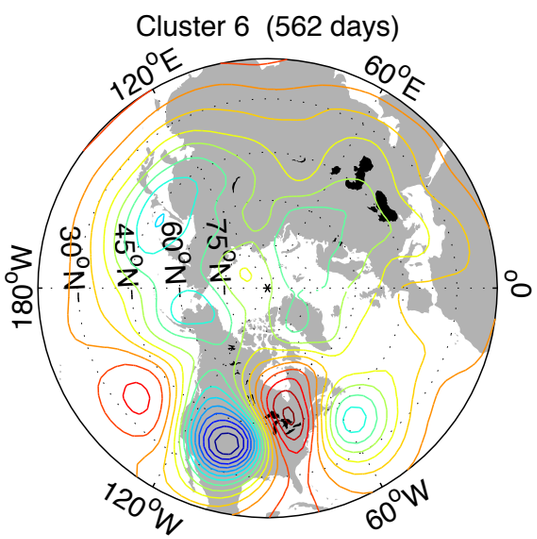








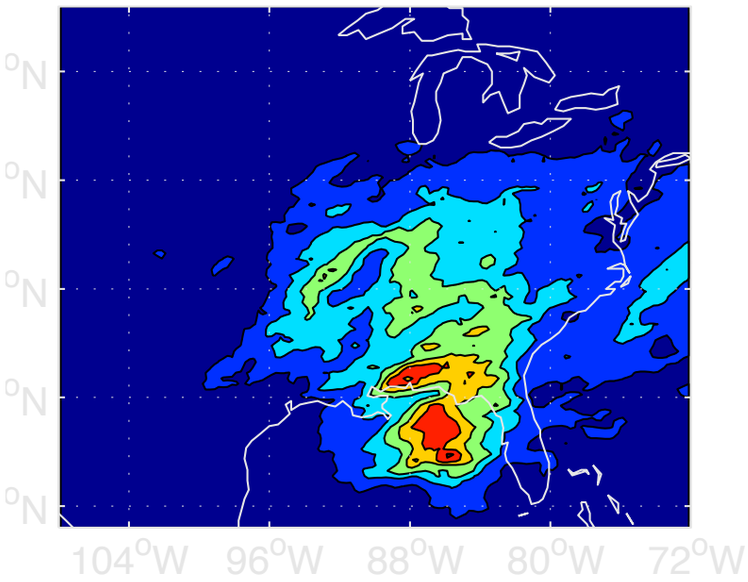




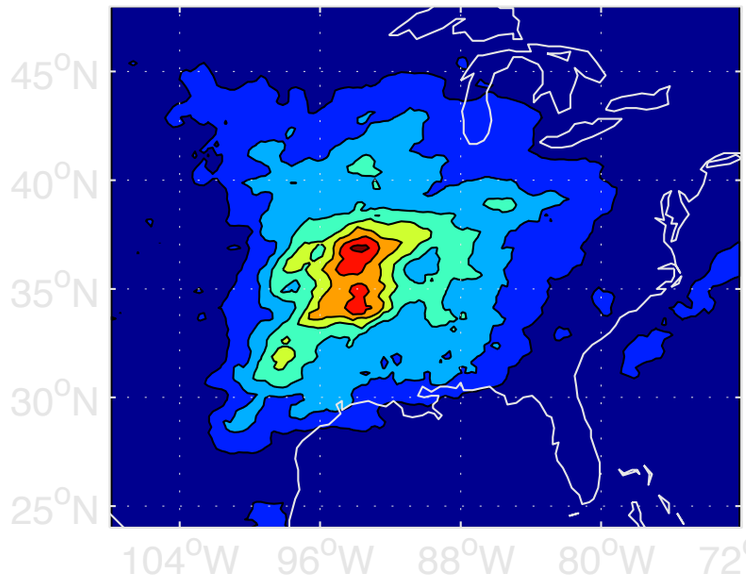
C.I. = 50 gpm

CMORPH Precipitation Composites (2005–2011)

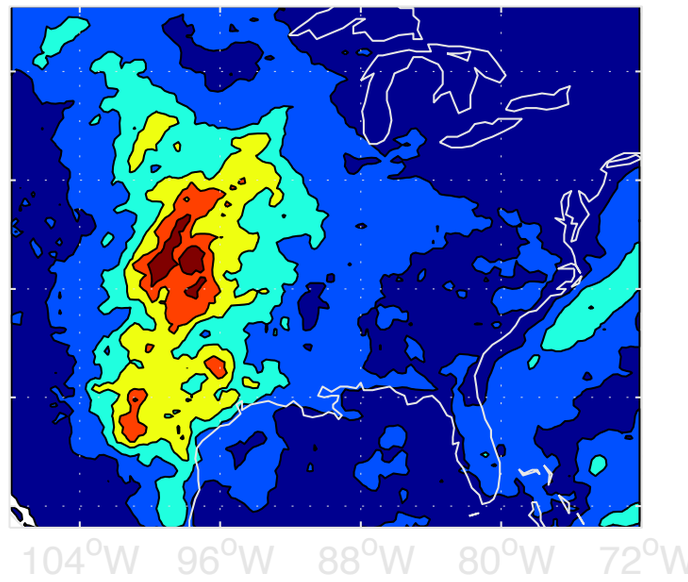
Cluster 1 (49 days)



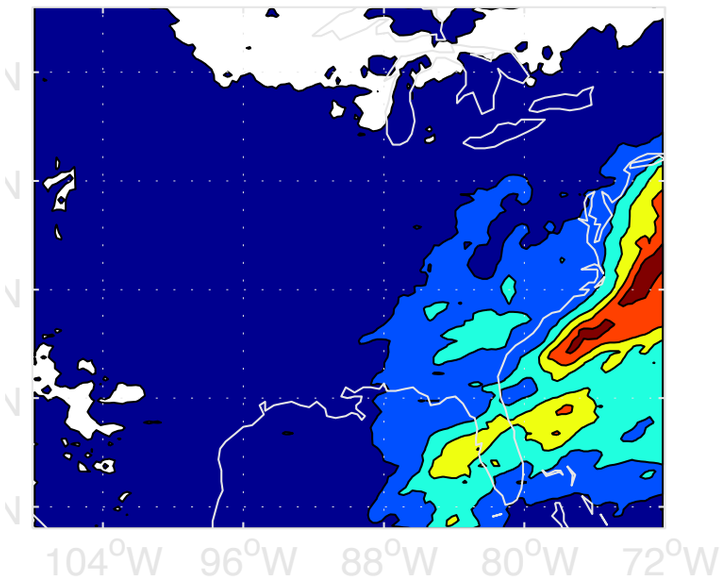
Cluster 2 (155 days)



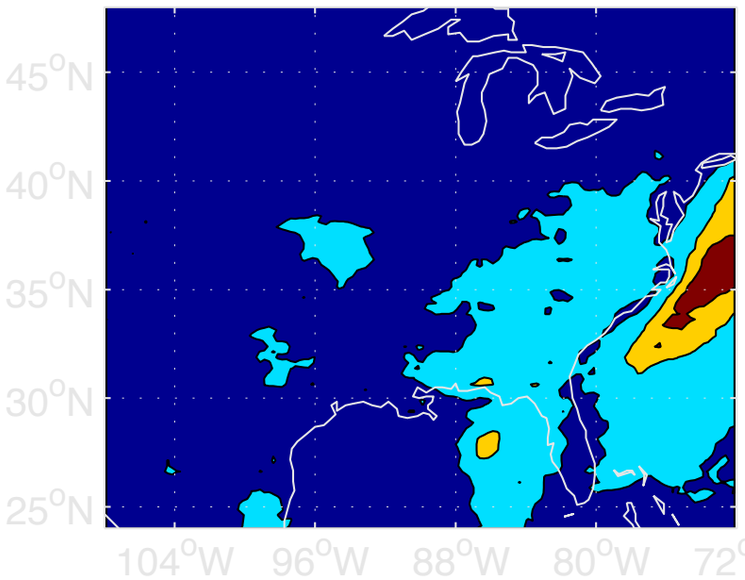
Cluster 3 (160 days)



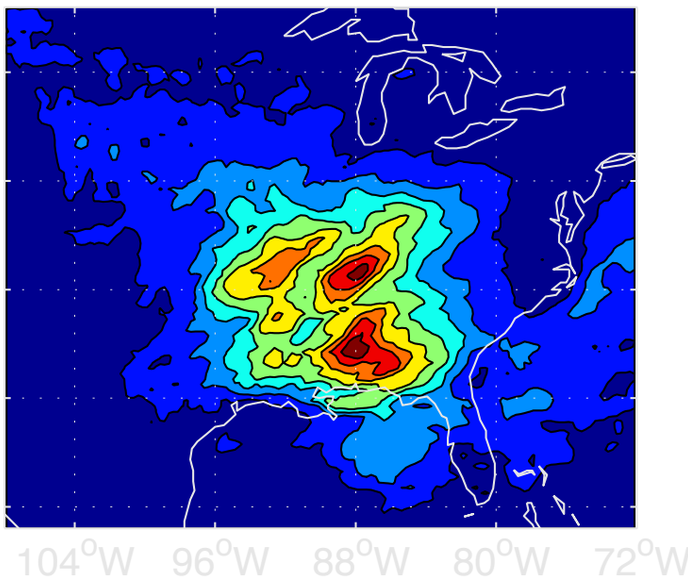
Cluster 4 (57 days)



Cluster 5 (146 days)

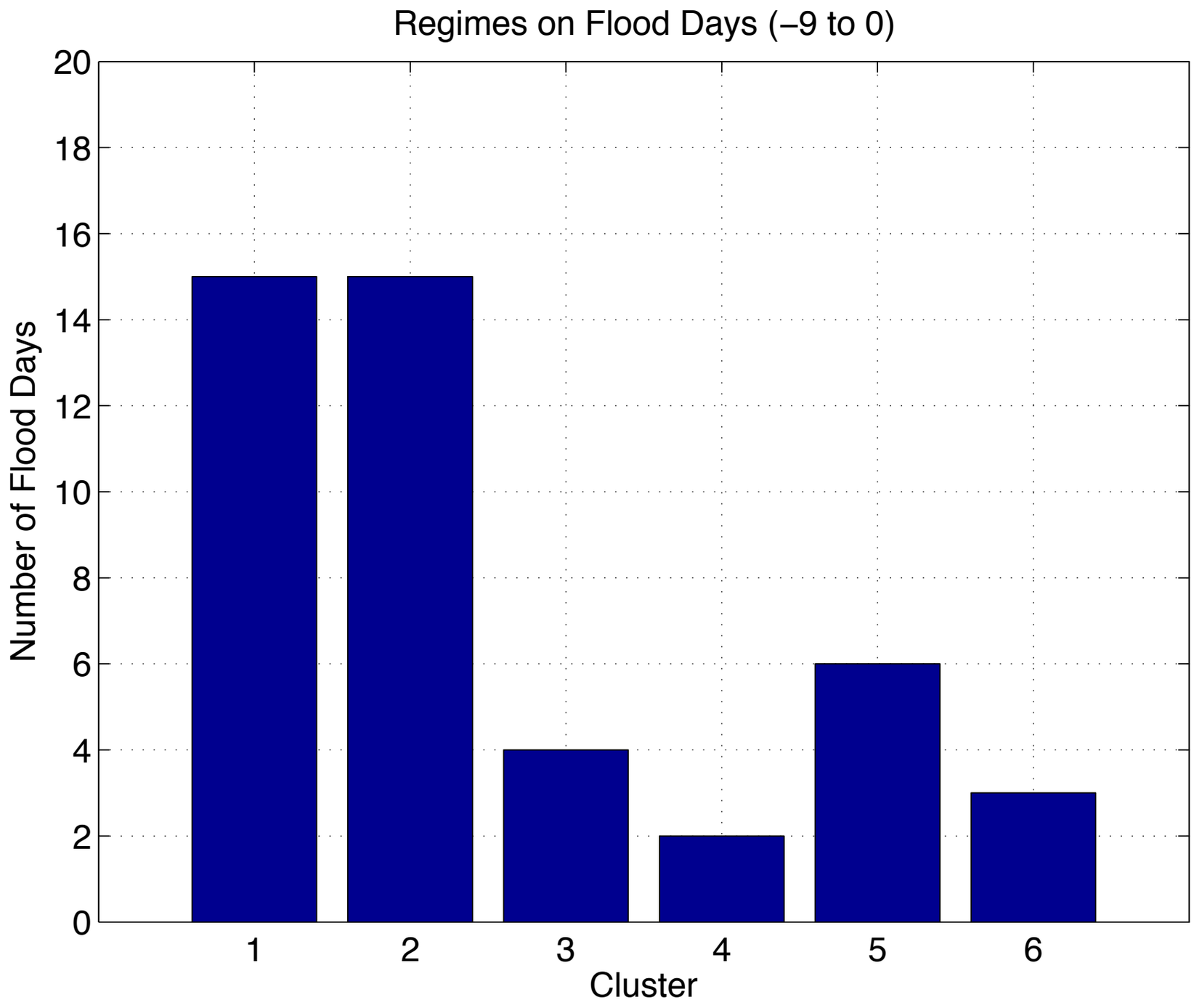


Cluster 6 (77 days)



C.I. = 2 mm/day

Clusters active during 5 major flooding events



13 May 1961,
5 March 1963,
10 March 1964,
25 May 1968,
4 May 1996

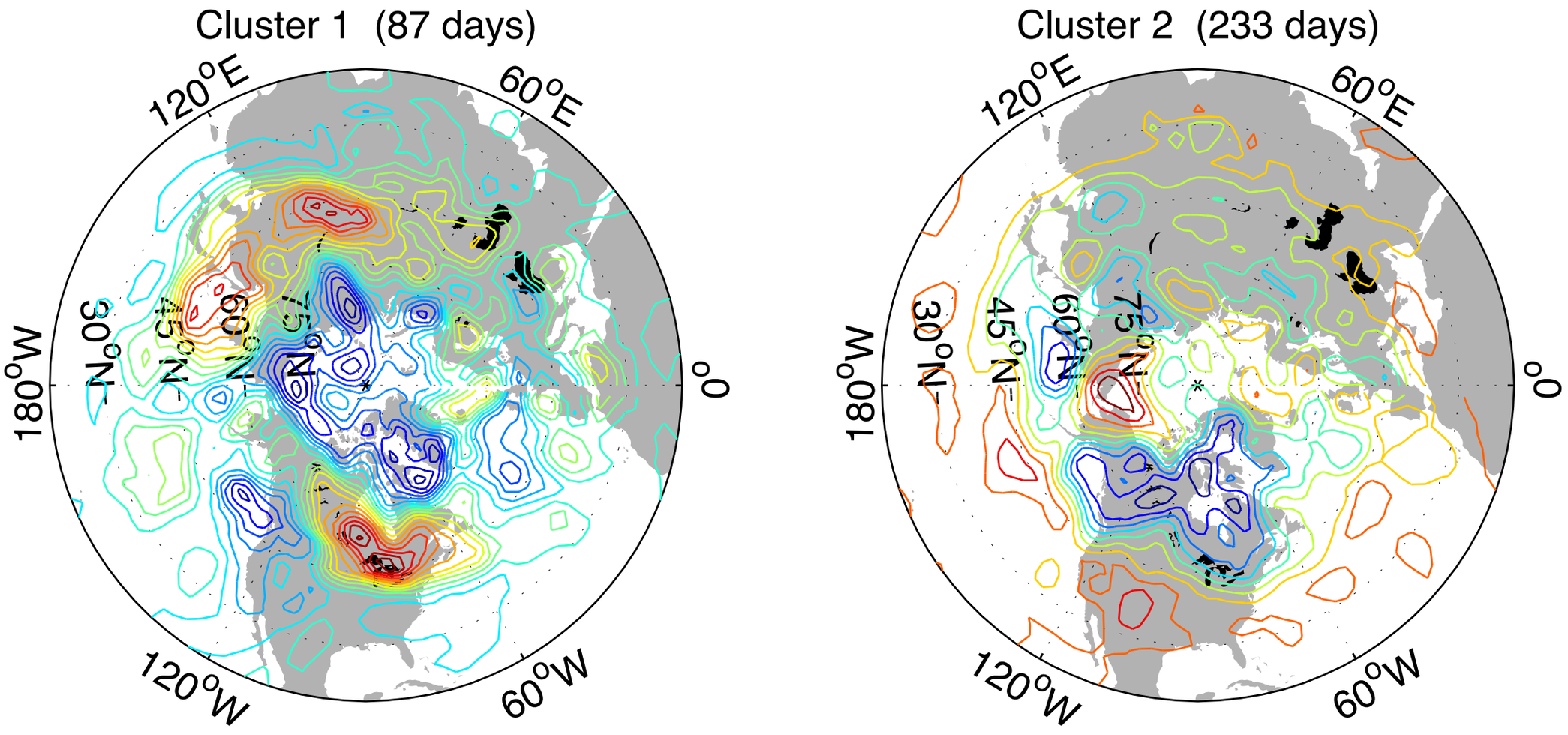
Circulation type transition matrix

to type ...

from type ...

	1	*2*	*3*	*4*	*5*	*6*
1	**53**	10	0	13	14	10
2	3	**60**	16	0	12	9
3	1	12	**78**	1	7	1
4	15	0	0	**63**	13	8
5	4	15	9	4	**59**	8
6	15	16	0	11	8	**51**

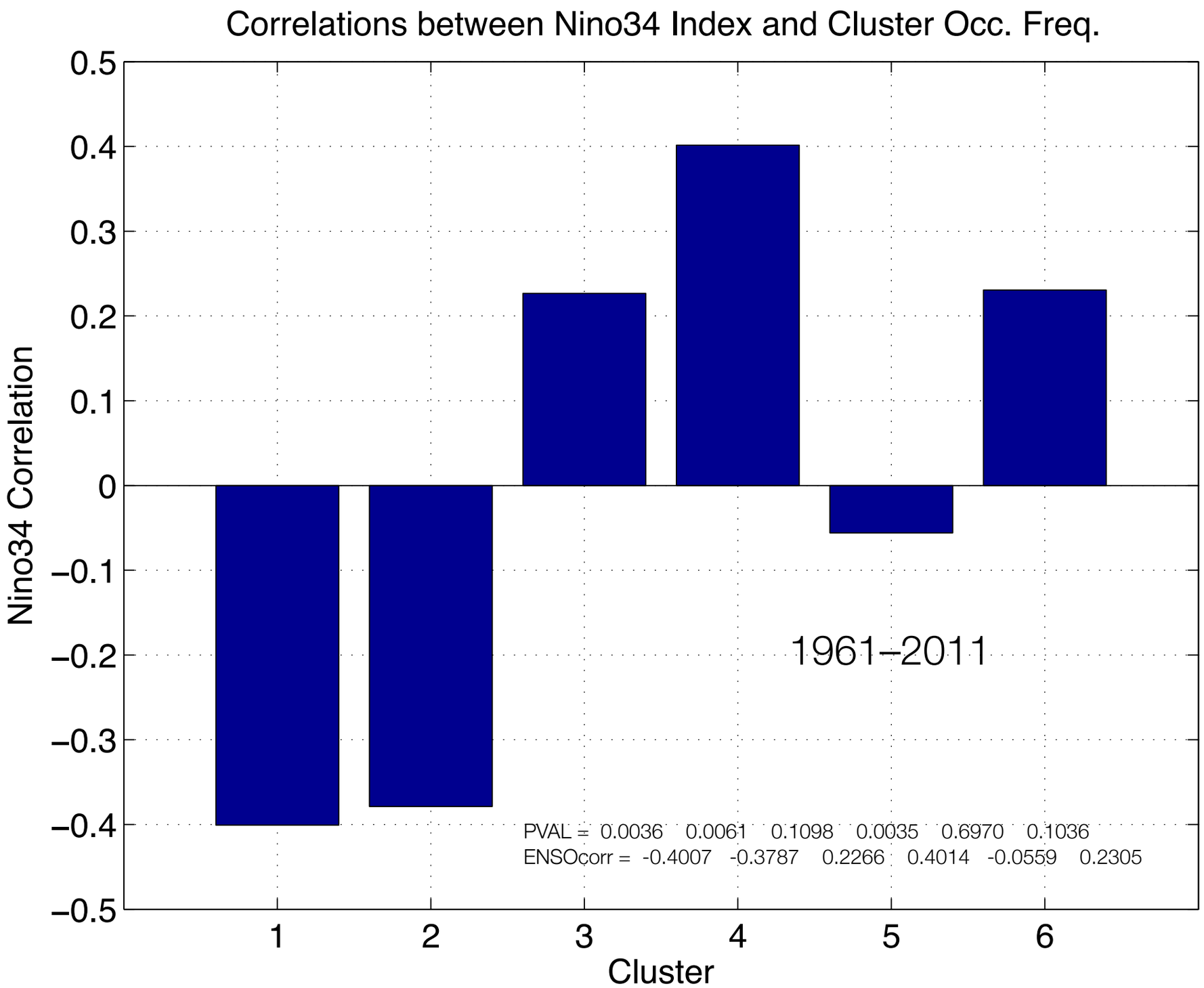
Potential vorticity anomalies on 315k isentrope



C.I. = 0.2 PVU

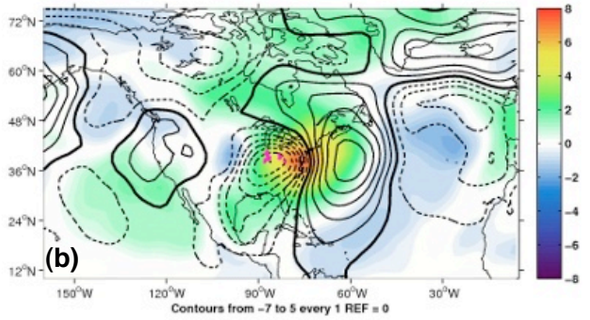
1. Interannual modulation of circulation type frequency?

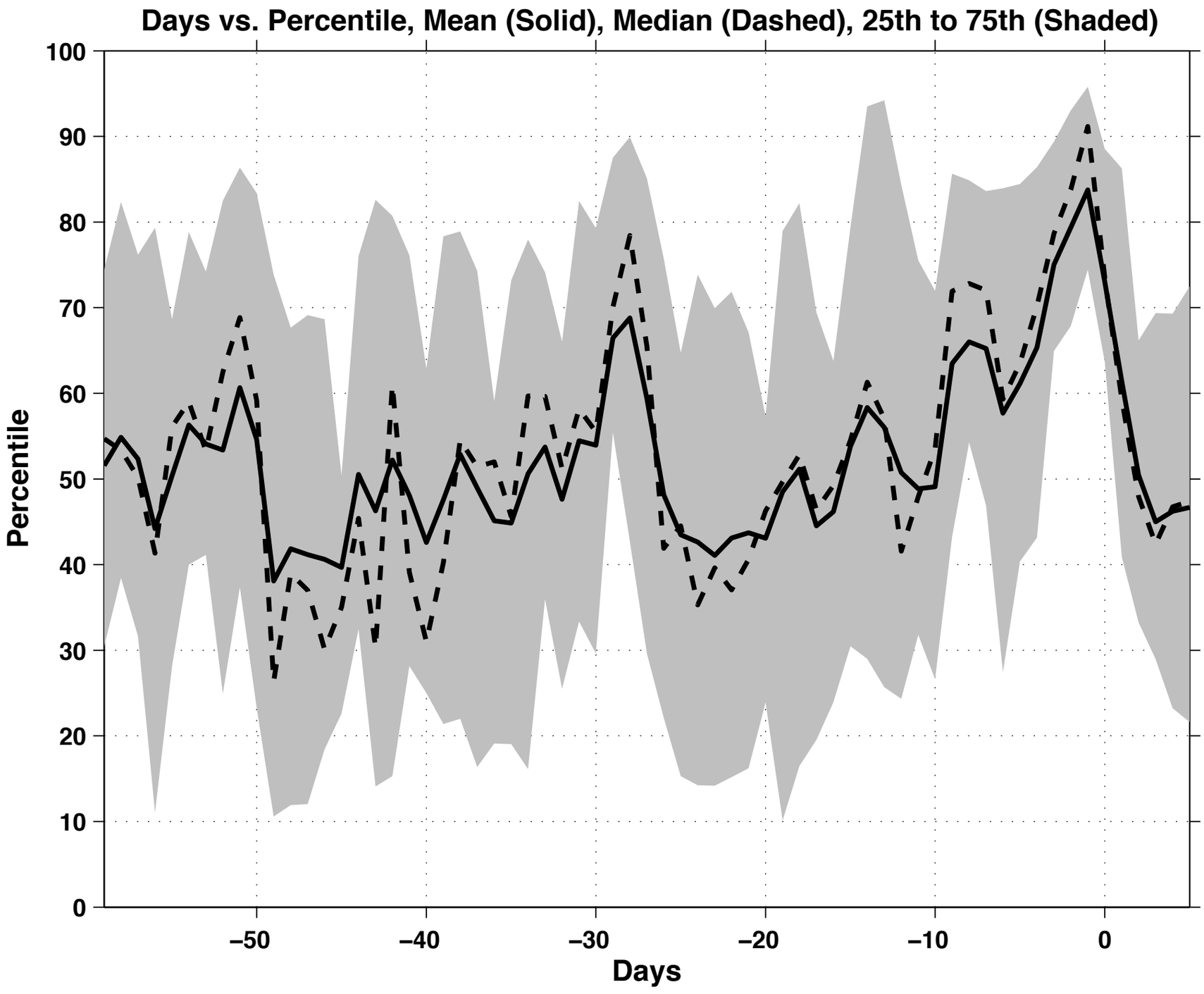
Association with ENSO



2. Role of intraseasonal oscillations in extreme flooding events?

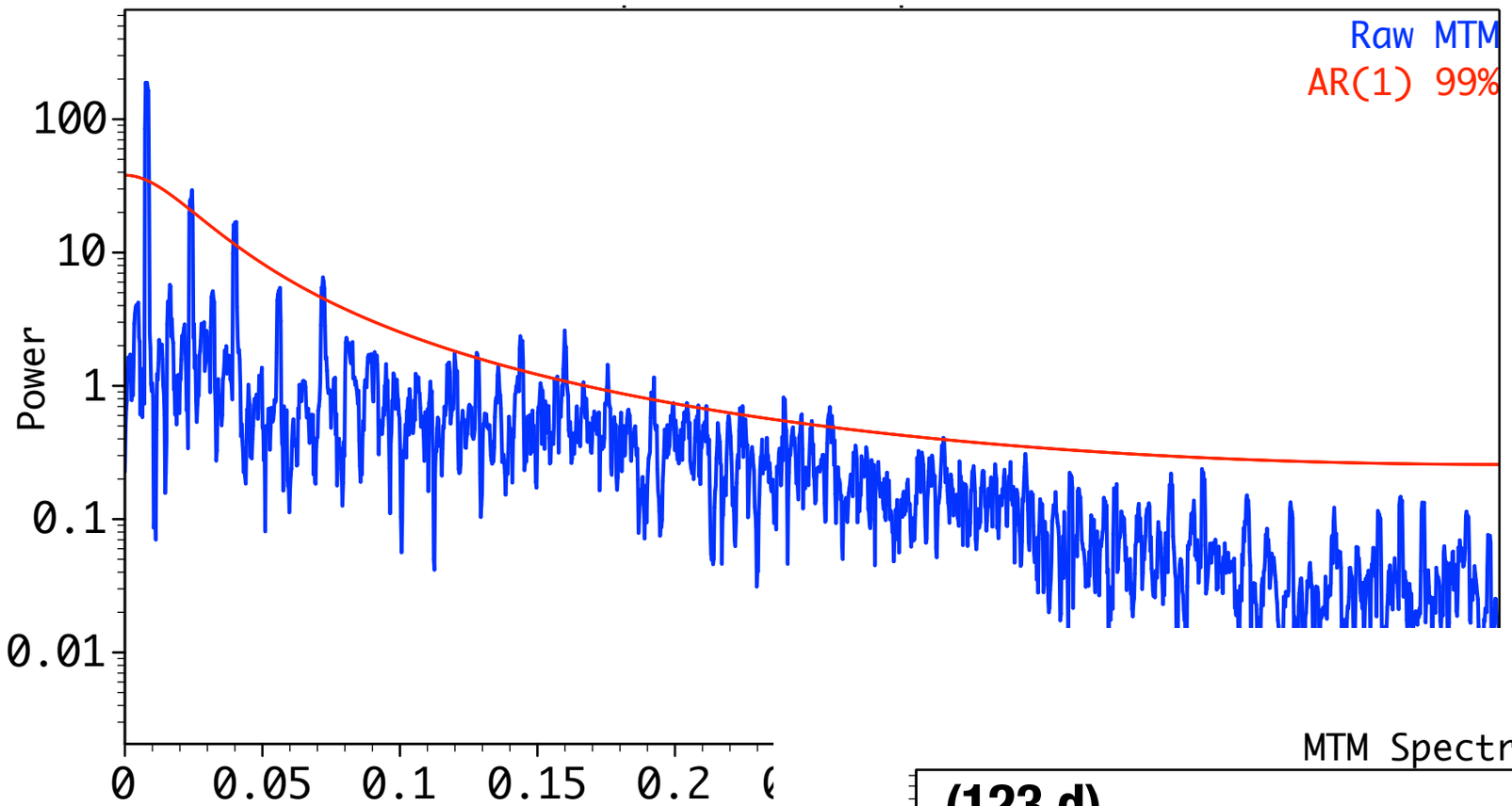
20-Event Composite “Dipole Index”

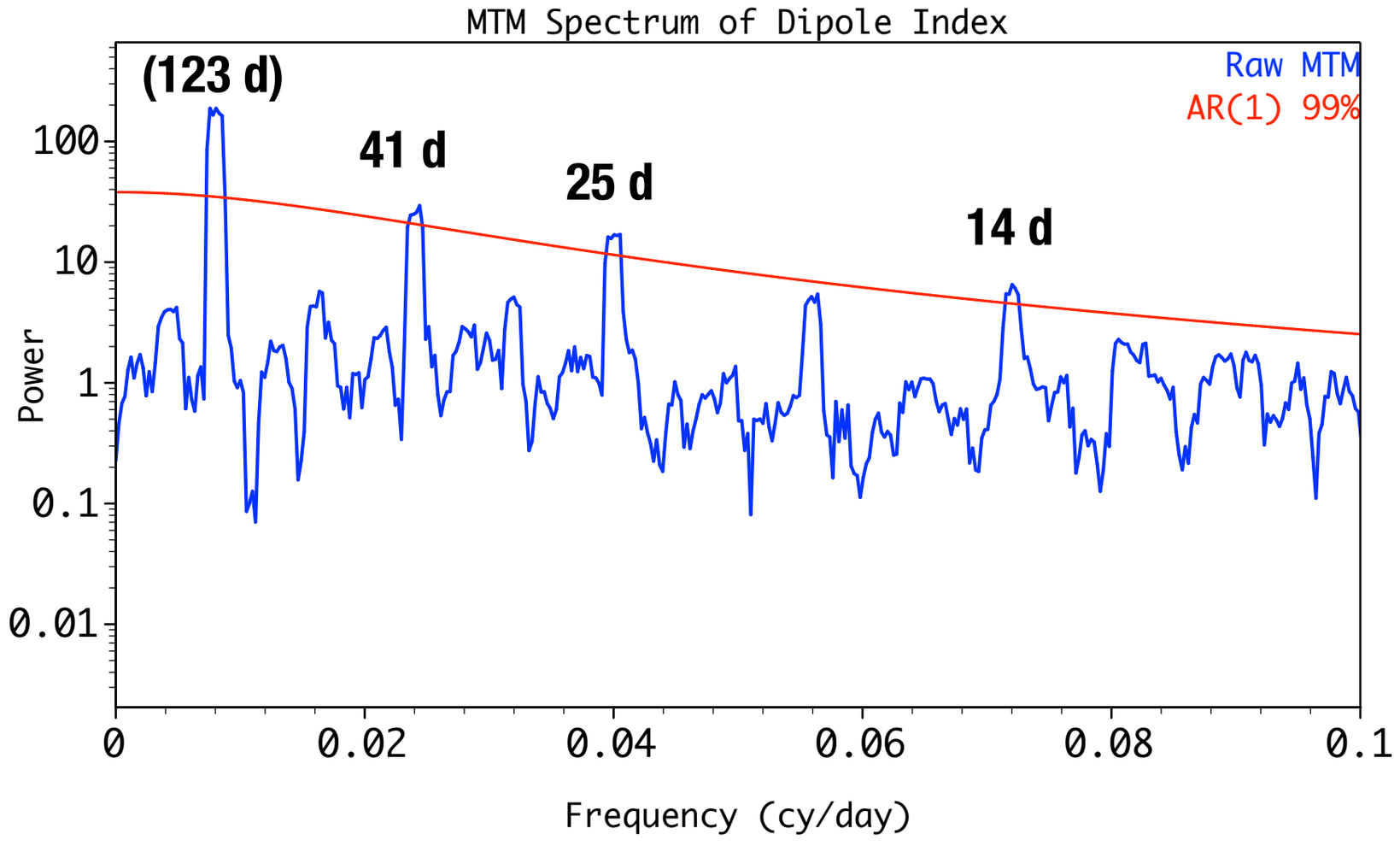




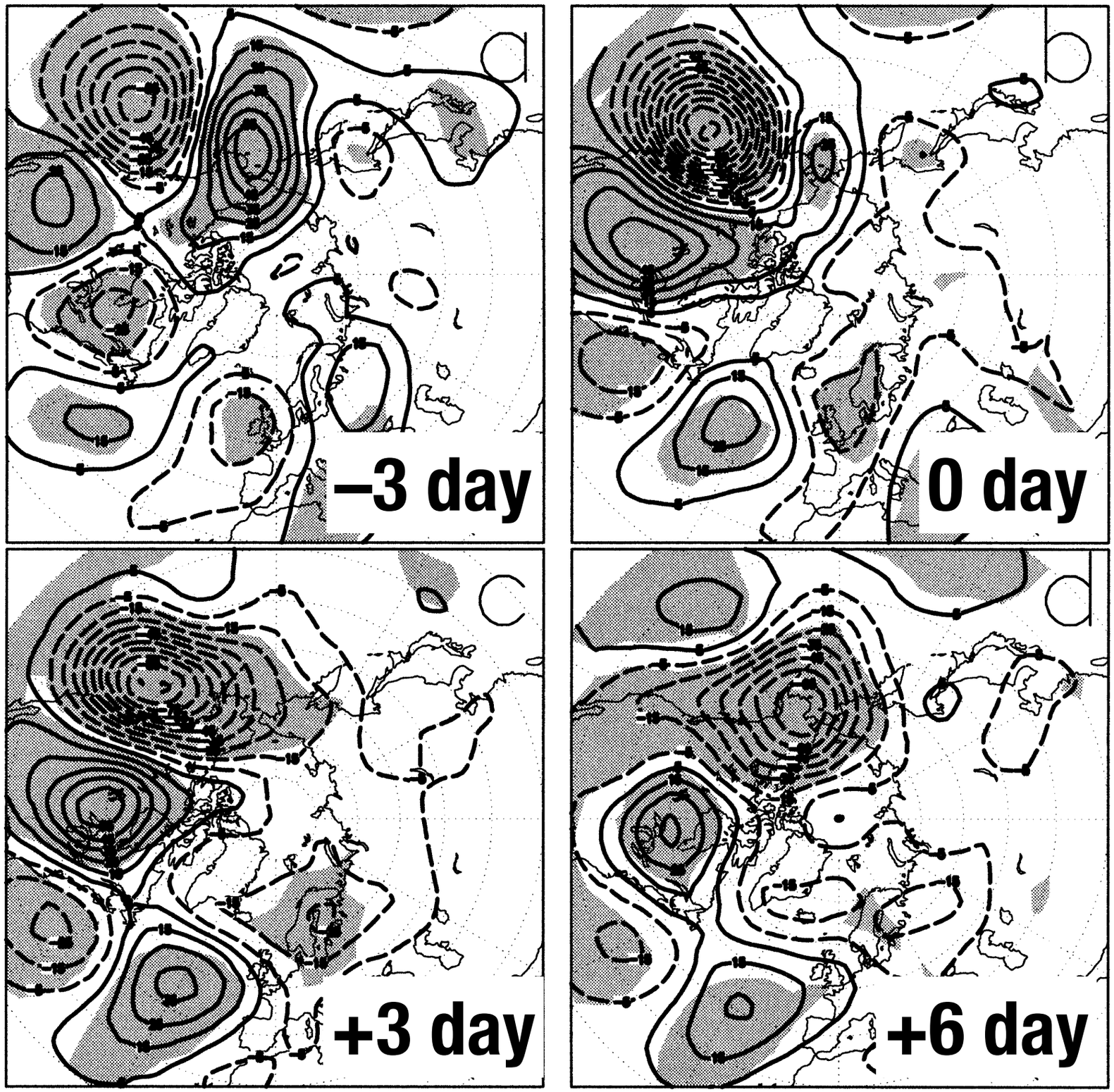
20-event composite mean (solid), median (dashed), and 25th to 75th percentile spread (shaded grey) of days (-59 to 5, where 0 is the flood date) vs. percentile relative to a Jan-May 1901-2008 climatology) of 700 mb height high minus low centers at day -1.

Multi-Taper Spectrum of Dipole Index



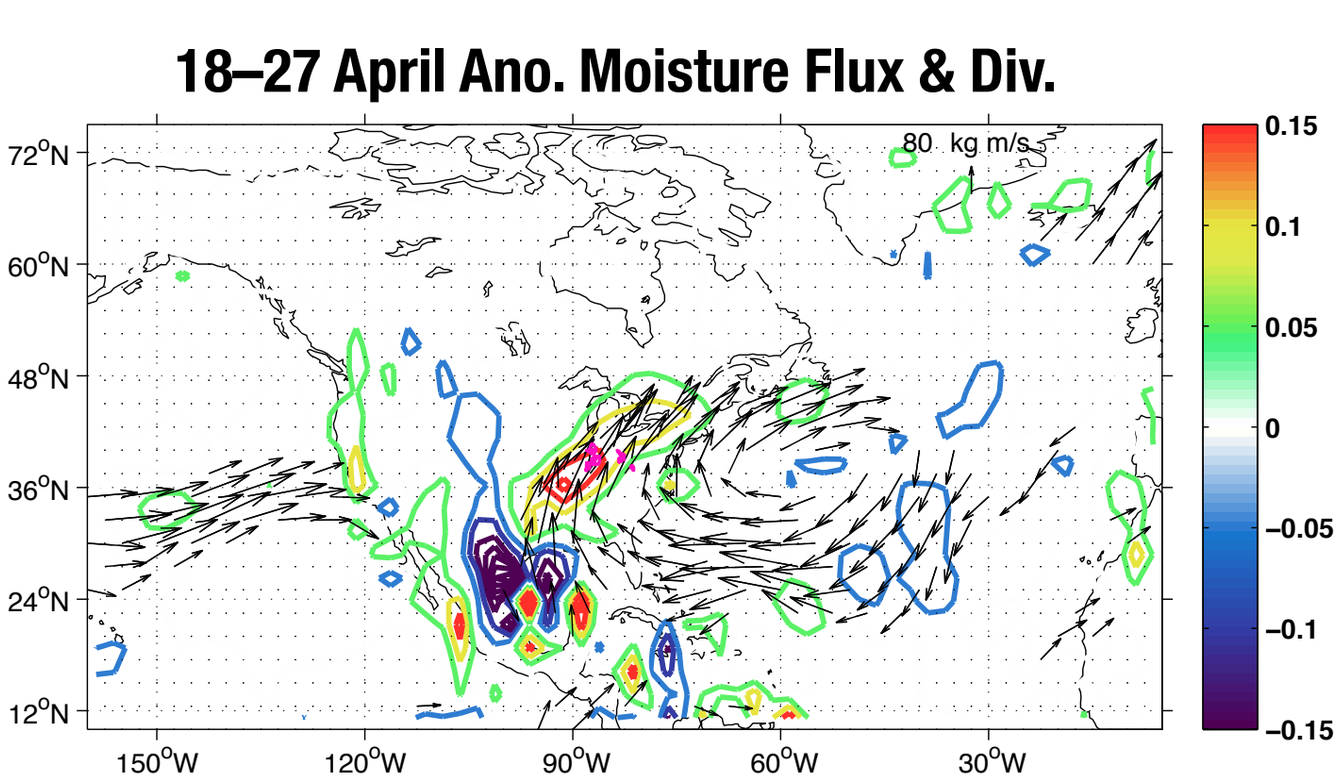


Composite anomalies of Z700 maps keyed to 20–30-day signal in Rockies mountain torque

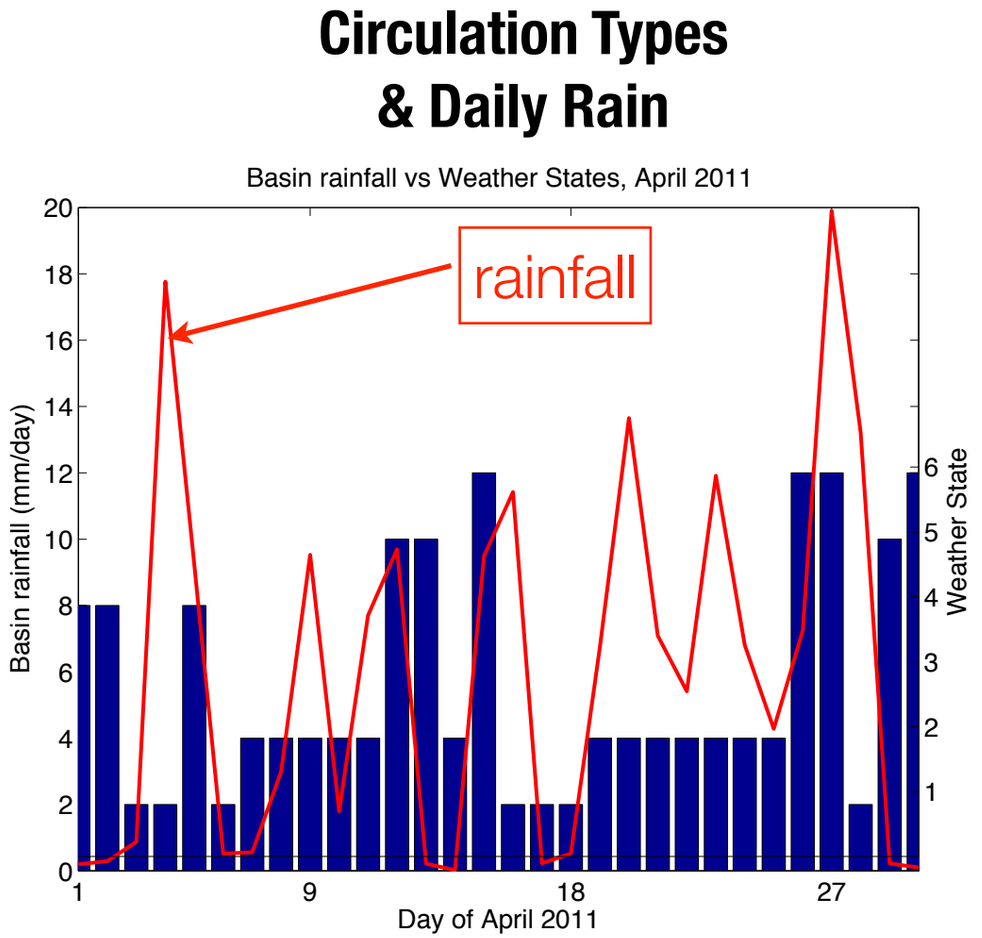


Lott et al. (1995)

April 2011 event



Nakamura et al. (GRL, submitted)



Conclusions

- Extreme flood dates are associated with dipolar geopotential height anomalies with nodal line near 70–80W
- HMM rainfall states show this is associated with synoptic wave propagation
- Circulation types show that 10-day build-up to flood dates are associated with two patterns: (1) the synoptic dipole, (2) a deep trough over E Canada
  - Both patterns occur preferentially during La Niña
- Flood events appear to be associated with intraseasonal oscillations, with significant spectral peaks near 14, 25 and 41 days