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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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

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cycle: 1->2->4->6->5->1
Composites of 700mb geopotential anomalies for each HMM rainfall state

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

![Graph showing classifiability index with K=6 indicated]
Six-cluster solution:
700mb Geopotential Height Anomalies

C.I. = 20 gpm
With vertically-integrated moisture flux anomaly composites superimposed.

Cluster 1 (532 days)
Cluster 2 (1039 days)
Cluster 3 (1101 days)
Cluster 4 (504 days)
Cluster 5 (954 days)
Cluster 6 (562 days)

C.I. = 20 gpm
Z-500 anomaly composites

Cluster 1  (532 days)
Cluster 2  (1039 days)
Cluster 3  (1101 days)
Cluster 4  (504 days)
Cluster 5  (954 days)
Cluster 6  (562 days)

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

Regimes on Flood Days (−9 to 0)

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

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Potential vorticity anomalies on 315k isentrope

Cluster 1  (87 days)
Cluster 2  (233 days)
Cluster 3  (226 days)
Cluster 4  (61 days)
Cluster 5  (211 days)
Cluster 6  (102 days)

C.I. = 0.2 PVU
1. Interannual modulation of circulation type frequency?
Association with ENSO

Correlations between Nino34 Index and Cluster Occ. Freq.

Cluster Nino34 Correlation

PVAL = 0.0036 0.0061 0.1098 0.0035 0.6970 0.1036
ENSOcorr = -0.4007 -0.3787 0.2266 0.4014 -0.0559 0.2305

1961–2011
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.
Composite anomalies of Z700 maps keyed to 20–30-day signal in Rockies mountain torque

Lott et al. (1995)
April 2011 event

18–27 April Ano. Moisture Flux & Div.

Nakamura et al. (GRL, submitted)

Circulation Types & Daily Rain

Basin rainfall vs Weather States, April 2011

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