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# Atmospheric Circulation Patterns and Physical Processes Associated with North American Temperature Extremes

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# Project Overview

- Phase 1: What are the atmospheric circulation patterns and physical processes associated with daily temperature extremes?
- Phase 2: How well do climate models simulate these patterns and processes?
- Phase 3: Will these patterns and processes be altered as a consequence of future changes in climate?

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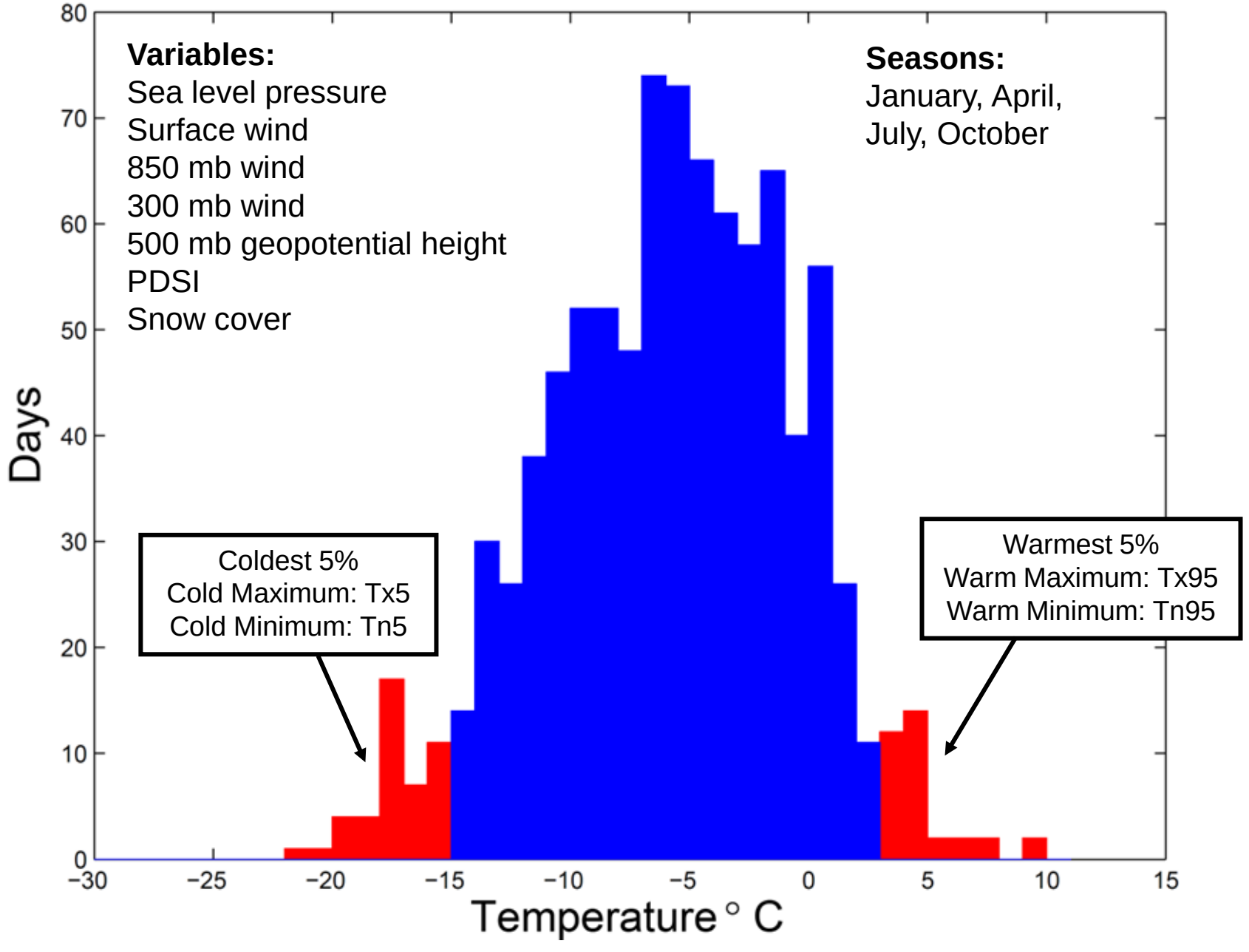
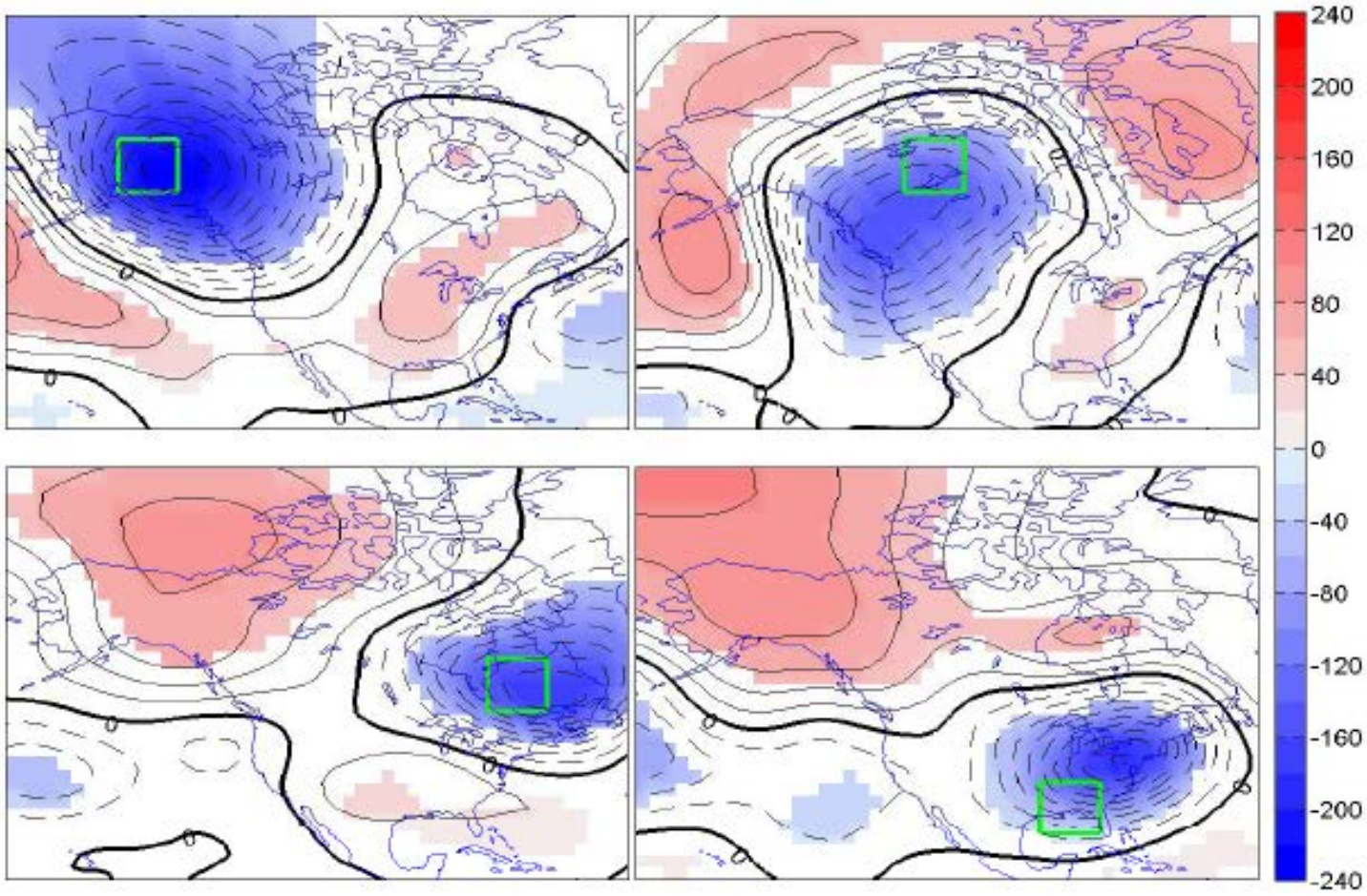
# Data and Methods

- HadGHCND (Caesar et al. 2006)
  - Collaboration between Hadley Centre and National Climatic Data Center
  - Daily maximum and minimum temperatures and anomalies
  - 2.5 ° latitude by 3.75 ° longitude, global domain
  - Period: 1946-2000
- NCEP/NCAR Reanalysis 1 (Kalnay et al. 1996)
  - 2.5 ° latitude by 2.5 ° longitude, global domain
- For grid points over North America, construct composite circulation patterns based on events in the tails of the daily temperature distribution.

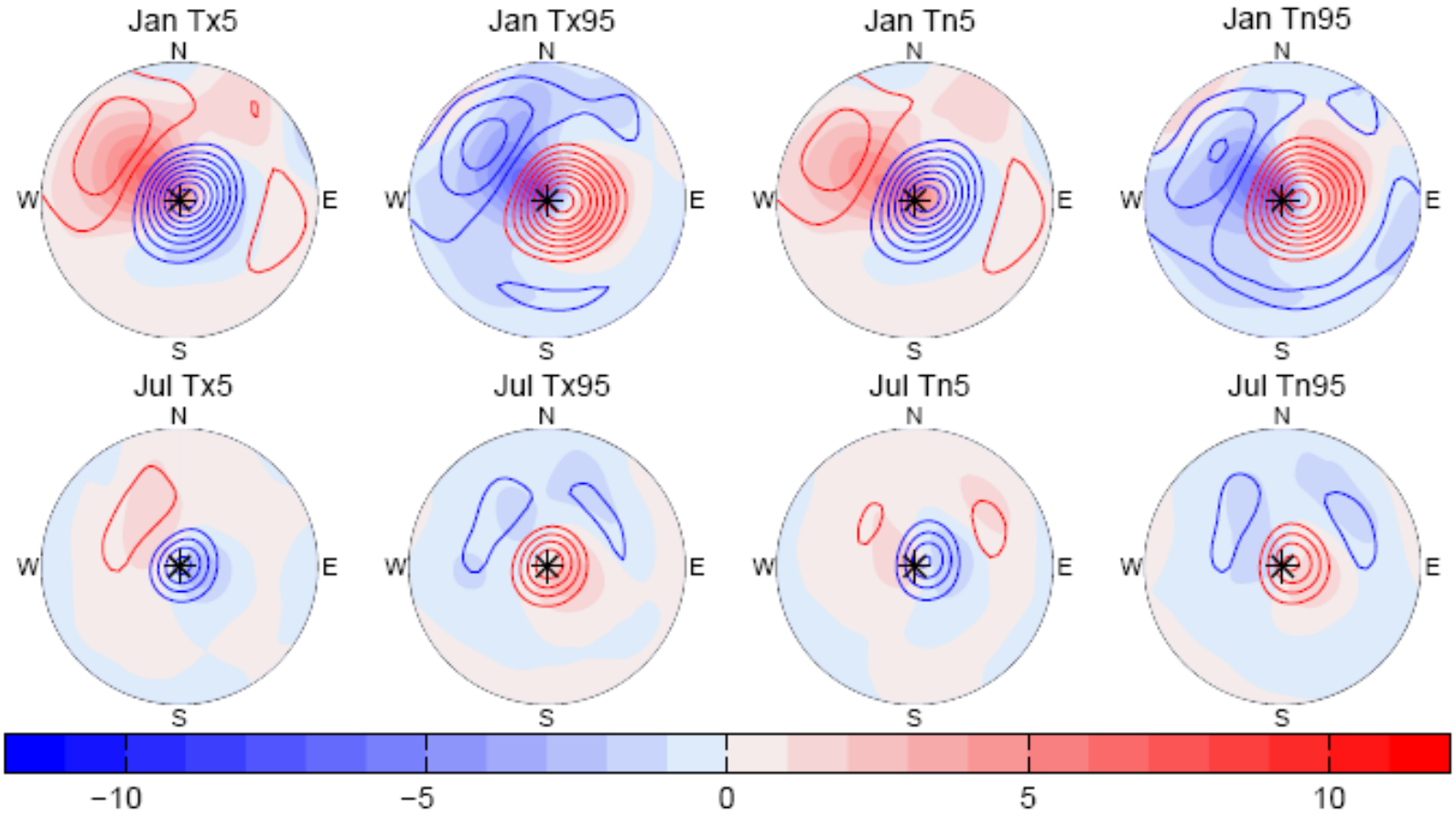

Variables:
Sea level pressure
Surface wind
850 mb wind
300 mb wind
500 mb geopotential height
PDSI
Snow cover
Seasons:
January, April,
July, October
Coldest 5%
Cold Maximum: Tx5
Cold Minimum: Tn5
Warmest 5%
Warm Maximum: Tx95
Warm Minimum: Tn95
Days
Temperature ° C
0
10
20
30
40
50
60
70
80
−30
−25
−20
−15
−10
−5
0
5
10
15

# Composite $Z_{500}$ anomalies for January Tx5




Composites based on temperature distribution at the locations of the green boxes.
Shading indicates anomalies are statistically significant at 5% level based on t-test.

# Grand composites: $Z_{500}$ and SLP

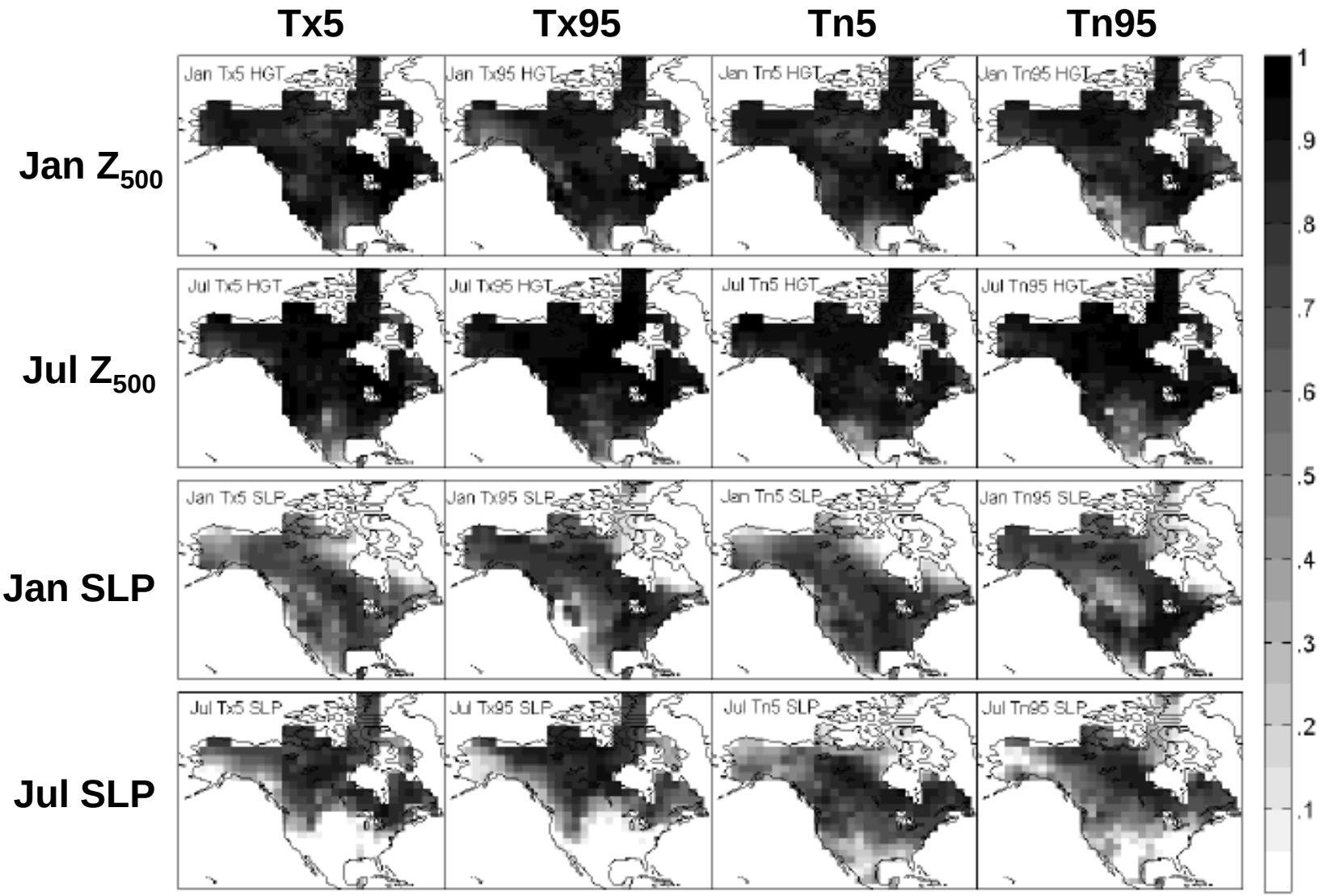



Contours: $Z_{500}$ anomalies (positive in red, negative in blue, interval: 18 m)
Shading: SLP anomalies (color scale above)
Radius of plotted area: 4500 km

# Variance associated with first EOF

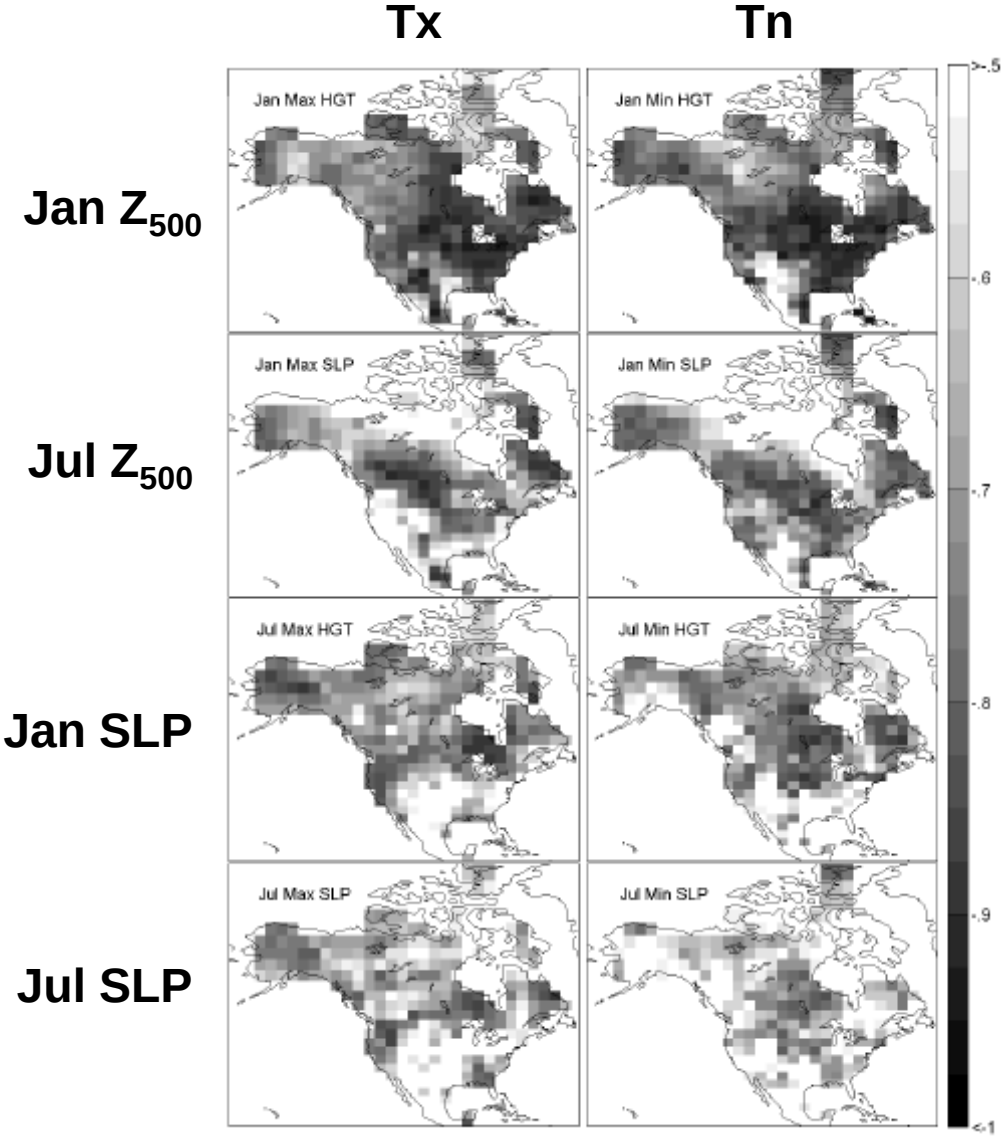
| | Tx5 | Tx95 | Tn5 | Tn95 |
|---|---|---|---|---|
| Jan $Z_{500}$ | 75% | 69% | 72% | 68% |
| Jul $Z_{500}$ | 78% | 84% | 76% | 81% |
| Jan SLP | 50% | 60% | 55% | 57% |
| Jul SLP | 41% | 39% | 48% | 37% |

# Pattern correlation: Local pattern vs. grand composite

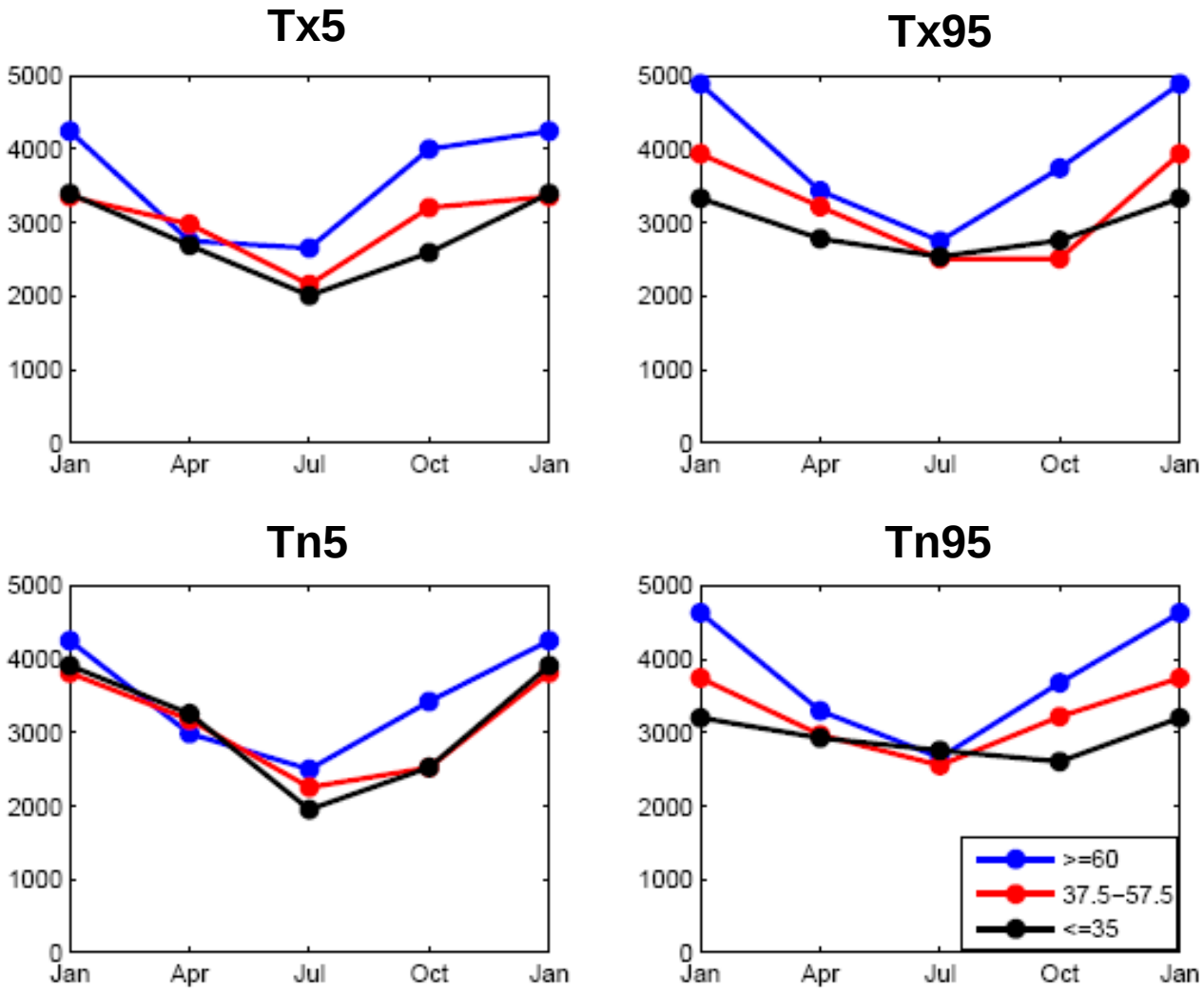


# Symmetry: Cold vs. warm

The pattern correlation between the local composites for the 5th and 95th percentiles is used as a metric of symmetry between cold and warm extremes. A pattern correlation of -1 would indicate that the patterns are perfectly symmetric.

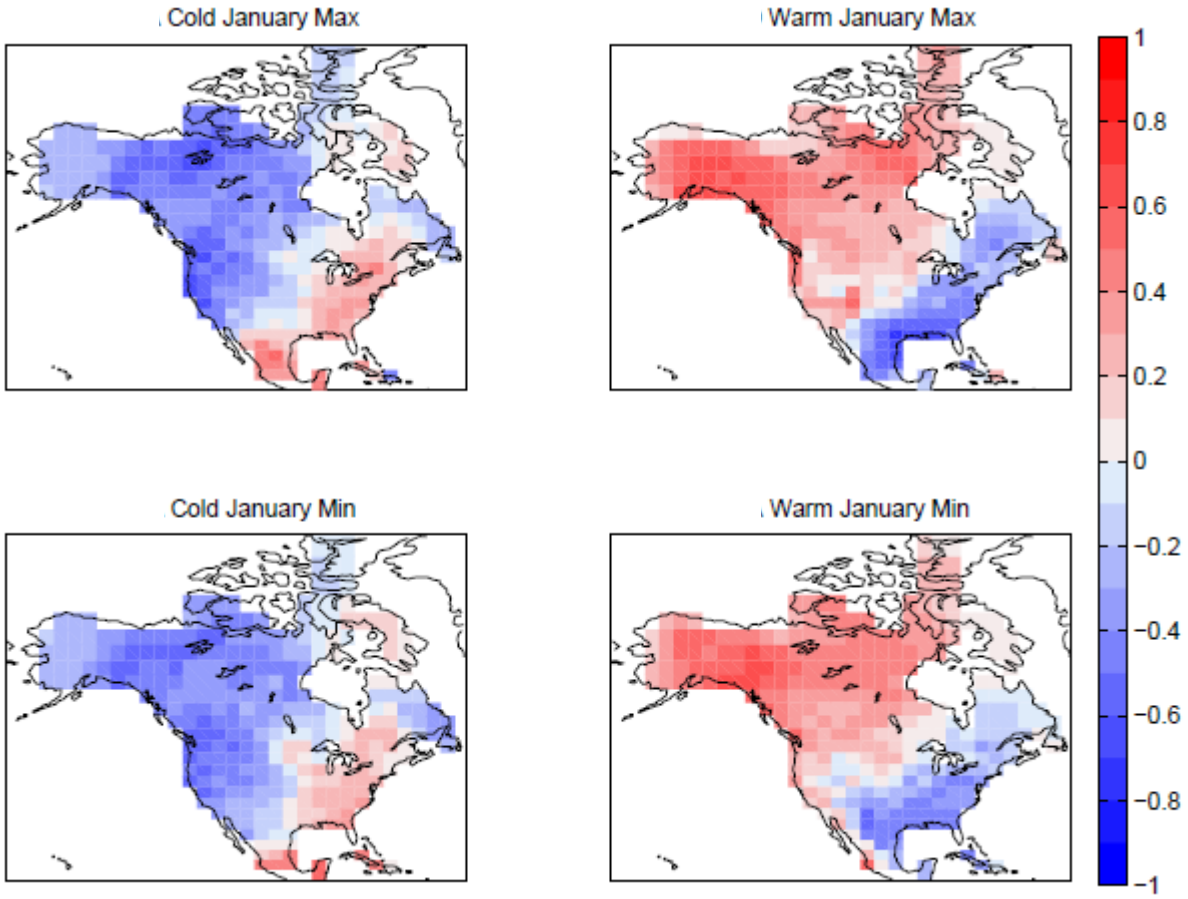


# Spatial scale: Half-wavelength of $Z_{500}$ pattern



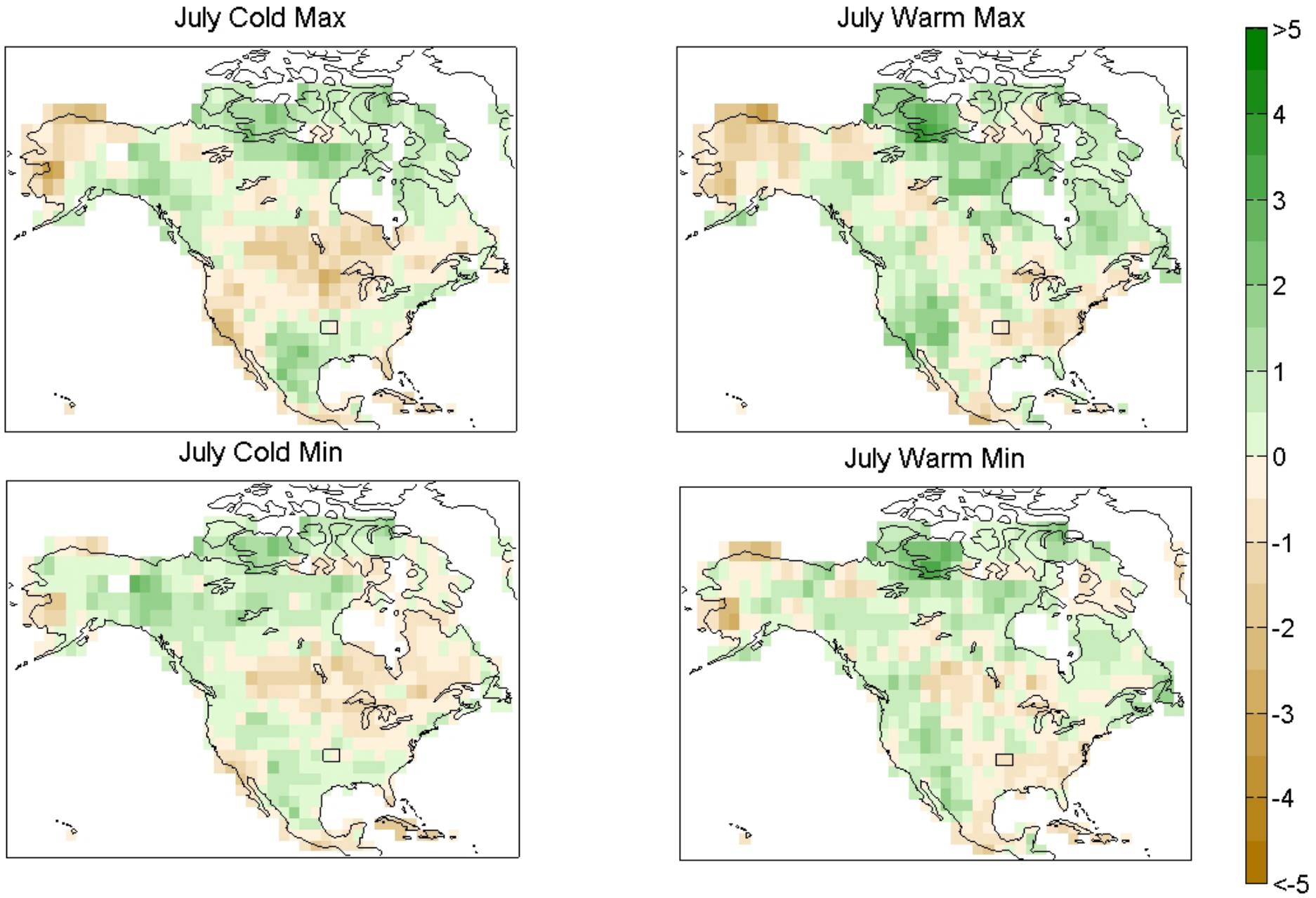

Units: km. Blue: ≥60 N, Red: 37.5-57.5 N, Black: ≤35 N

# Relationships with teleconnection patterns




Average value of index of Pacific-North American pattern
during extreme temperature events

# Influence of land surface: PDSI



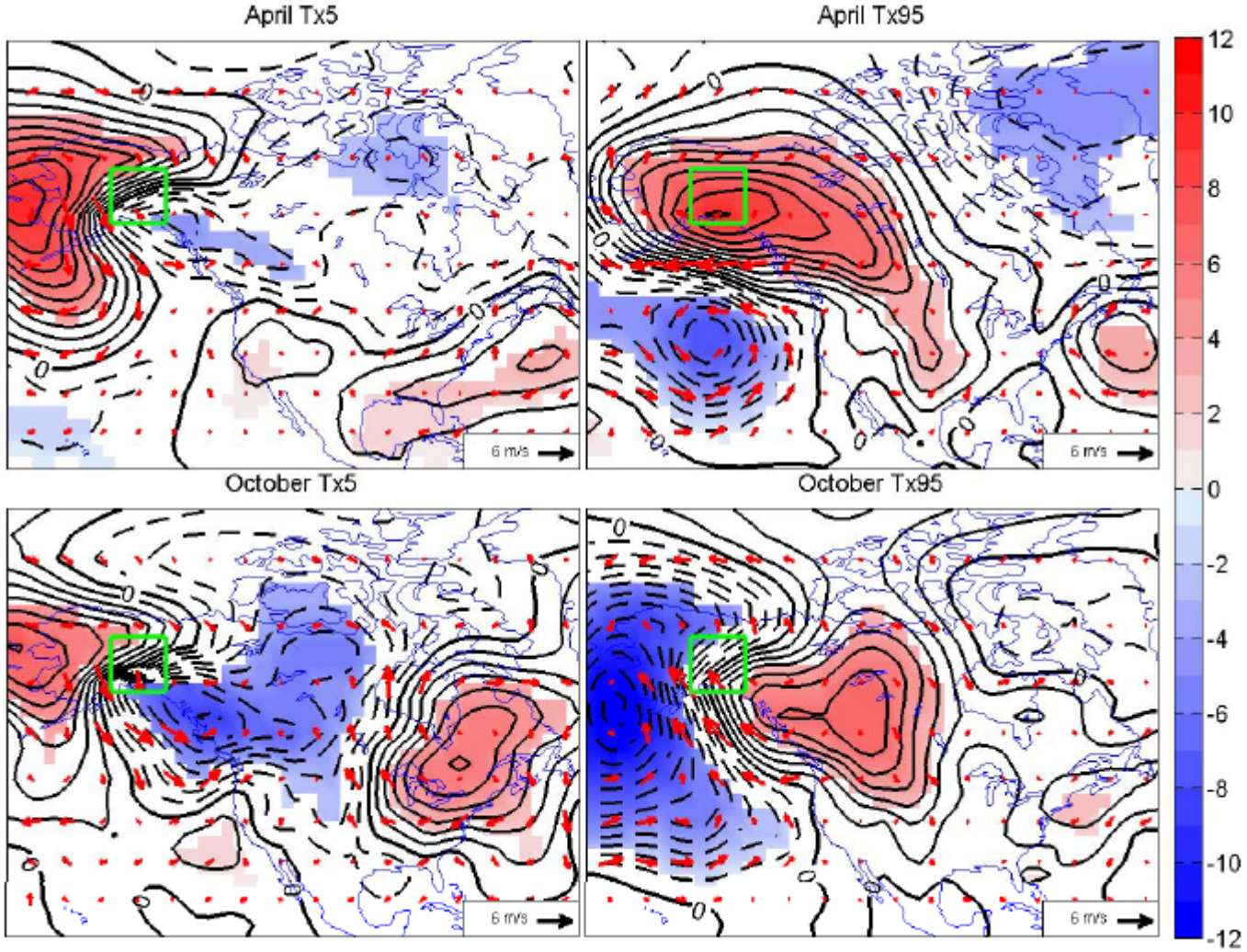
# Conclusions

- Warm events are generally associated with positive 500 mb height and SLP anomalies just downstream with negative anomalies farther upstream.
- The anomaly patterns associated with cold events tend to be similar to, but opposite in sign of, those associated with warm events, especially within the westerlies and away from marine and topographic influences.
- The orientation and spatial scale of these circulation patterns vary based on latitude, season, and proximity to mountains and coastlines.
- Circulation patterns aloft are more consistent across the continent than those at the surface.
- Circulation anomalies at some locations resemble those associated with recurrent large-scale teleconnection patterns.
- Land surface-atmosphere coupling appears to play a role in the occurrence of some types of extremes.

# Future activities

- A paper on this work is in preparation for *J. Climate* and will be submitted later this year.
- Output from historical climate simulations in the CMIP archives will be analyzed in the same way to determine how well climate models simulate the circulation patterns and physical processes associated with extreme daily temperatures.
- Output from future climate change simulations will be examined to determine if these patterns and processes will be altered as a consequence of future changes in climate.

# Local/regional effects in transition seasons




Contours: SLP anomalies (mb). Vectors: Surface wind anomalies.