Synoptic Environments Associated with Significant Tornadoes in the Contiguous United States

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Introduction

- Tornado forecasting is a challenge
- "Rules of Thumb" for synoptic conditions
  - Developed by Fawbush and Miller in 1950's
  - Has not been updated since Miller (1972)
  - Led to both synoptic patterns and environmental parameters that were deemed favorable for tornadoes
- **Goal: Creation of up-to-date documentation on the synoptic environments, and an increased recognition of significant tornado days based upon synoptic environments forecast by numerical models.**

Data & Methodology

- Data Sources & Interpretations
  - Synoptic Environment
    - » RUC GRIB Files from NOAA archive
      - Python scripting for objective classification of chosen key parameters
  - Surface & 500 hPa Charts
    - » HPC Online Archive
    - » RAP UCAR Image Archive
      - Subjective classifications of images
  - Data was collected at both tornado time and 12 hours previous to determine the change in synoptic environment

Data & Methodology

RUC Data Collected (274 Cases)

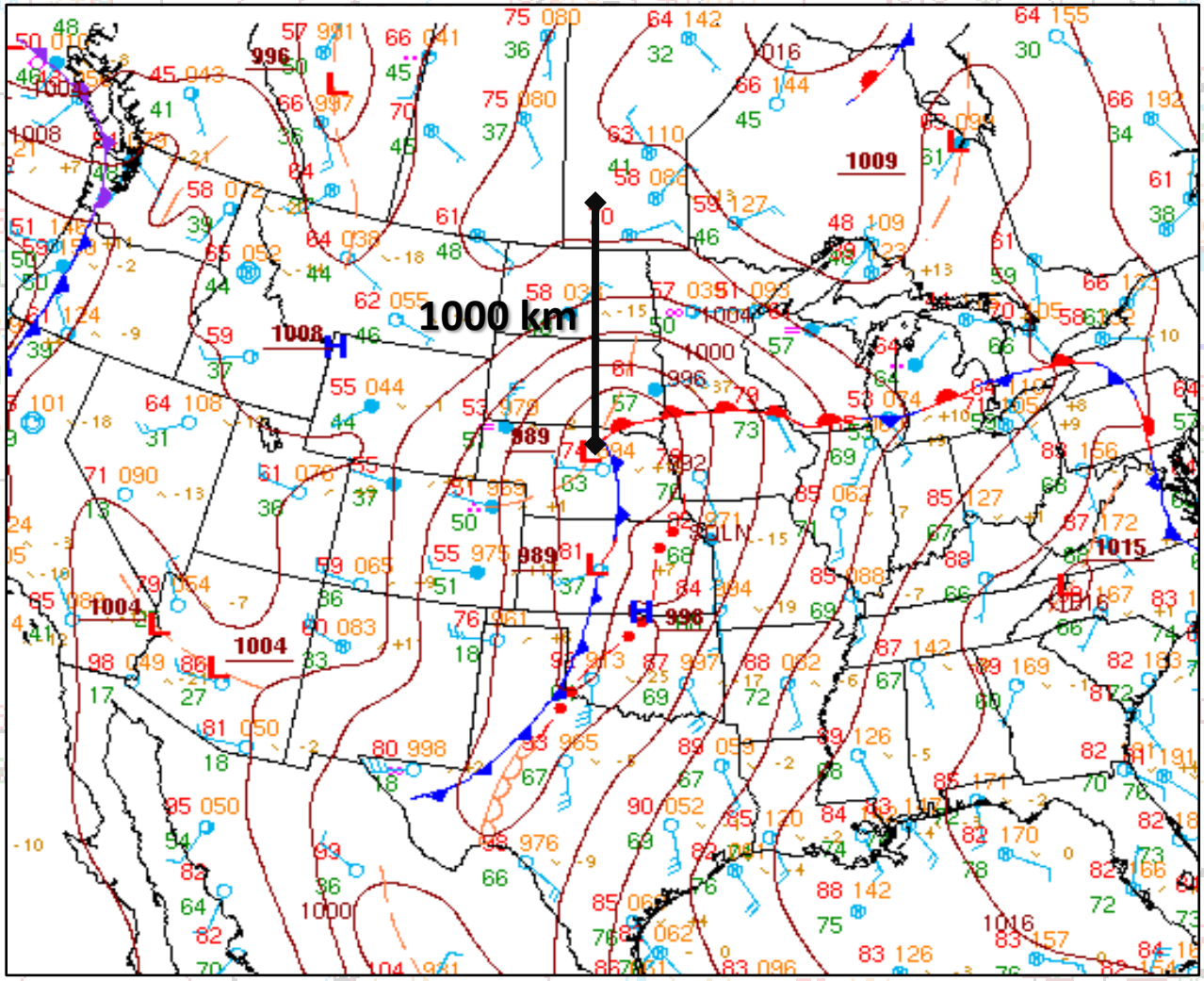
Parameter	300 hPa	500 hPa	700 hPa	850 hPa	Surface
Dew Point				X	X
Geopotential Height		X			
Sea Level Pressure					X
Temperature	X	X	X	X	X
Wind Direction	X	X		X	
Wind Speed	X	X		X	

Data & Methodology

Surface Low Classification

- Approximate greatest pressure gradient within 1000 km
- *Example Case:* 19 hPa change

Moderate Surface Low Pressure System

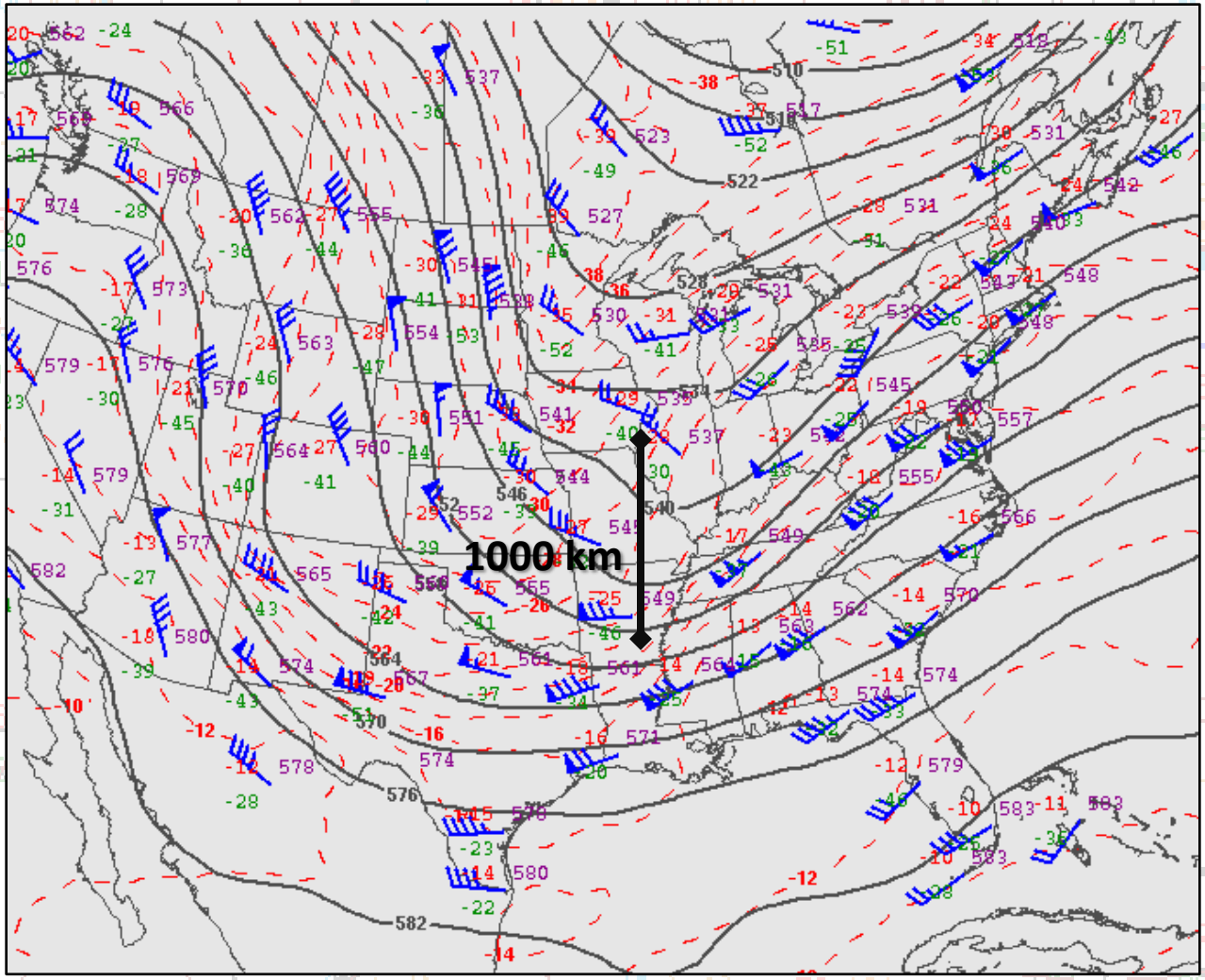


Data & Methodology

500 hPa Classification

- Approximate greatest height gradient along same latitude within 1000 km
- *Example Case:*
  70 meter change

  Moderate Amplitude 500 hPa Synoptic Regime

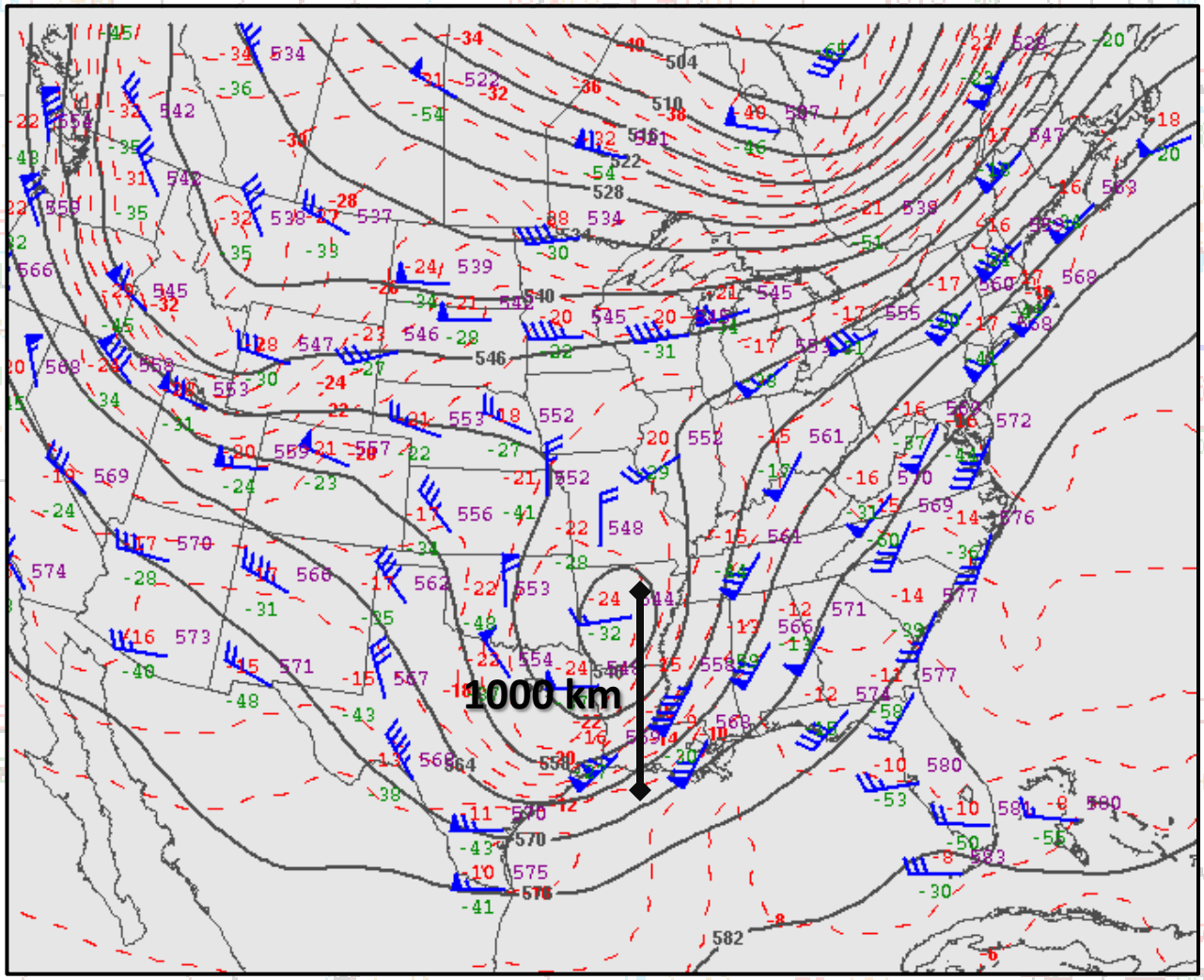


Data & Methodology

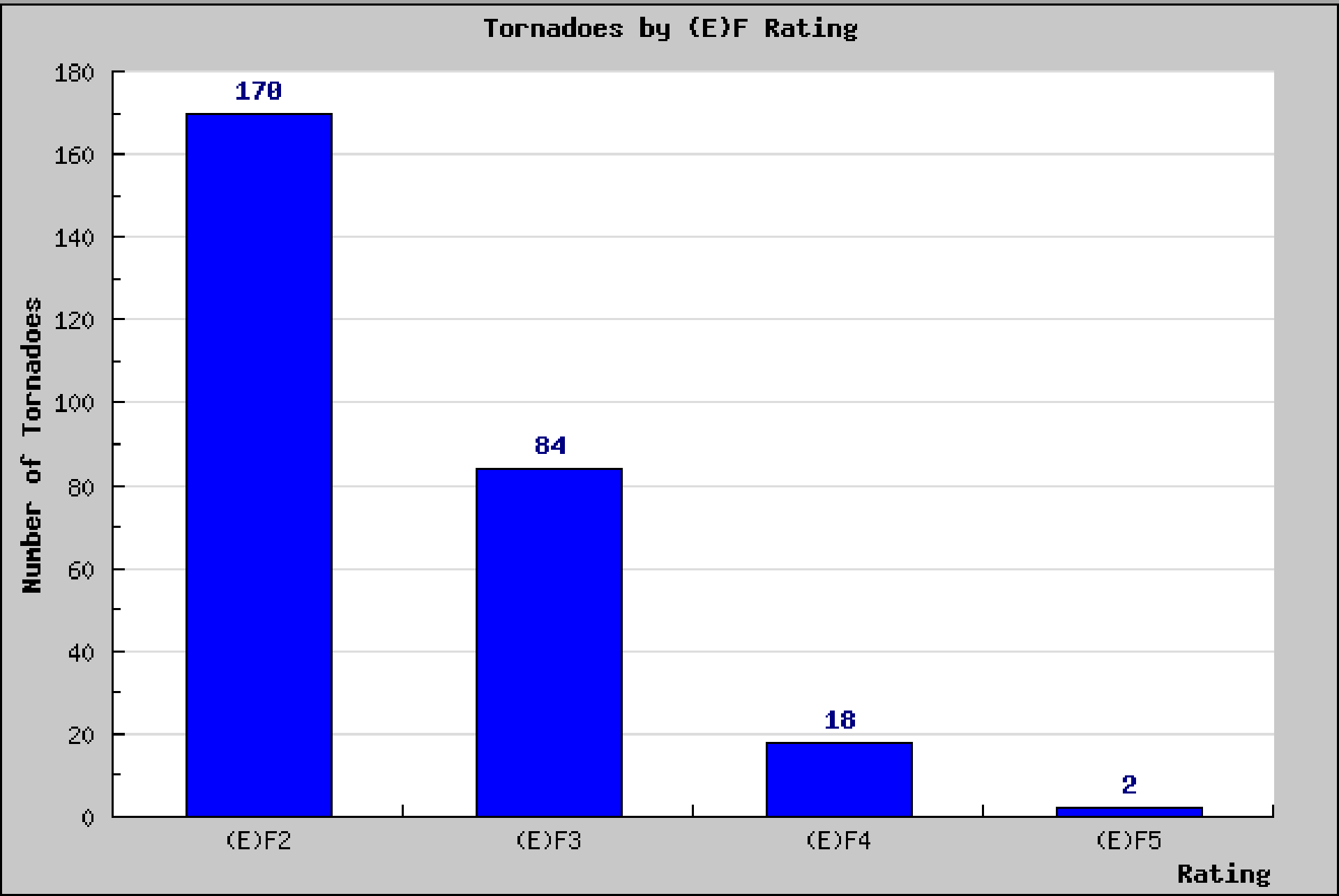
500 hPa Classification

- Approximate greatest height gradient along same latitude within 1000 km
- *Example Case:* 100 meter change

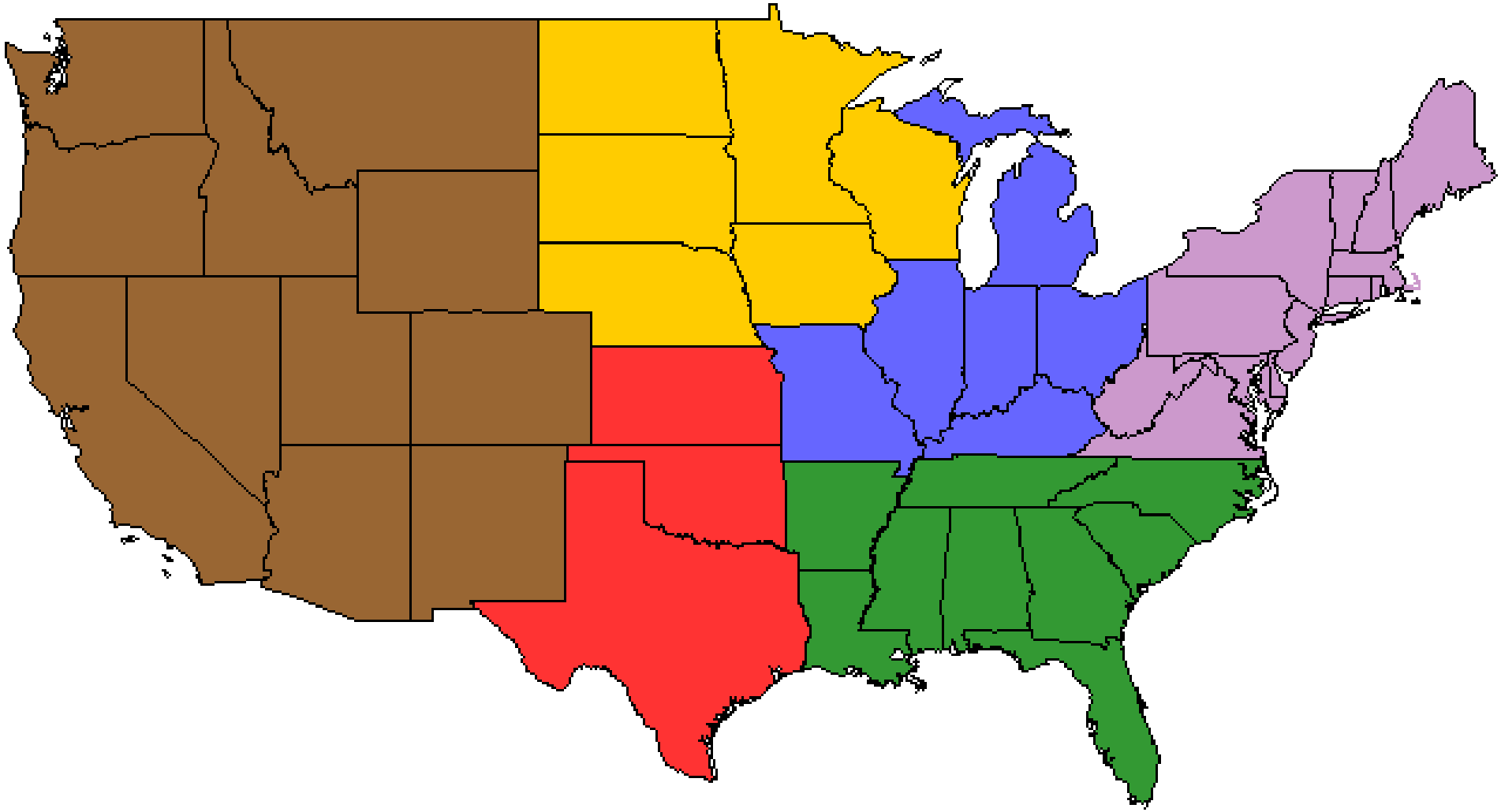
Intense Closed 500 hPa Synoptic Regime



Tornado Distribution



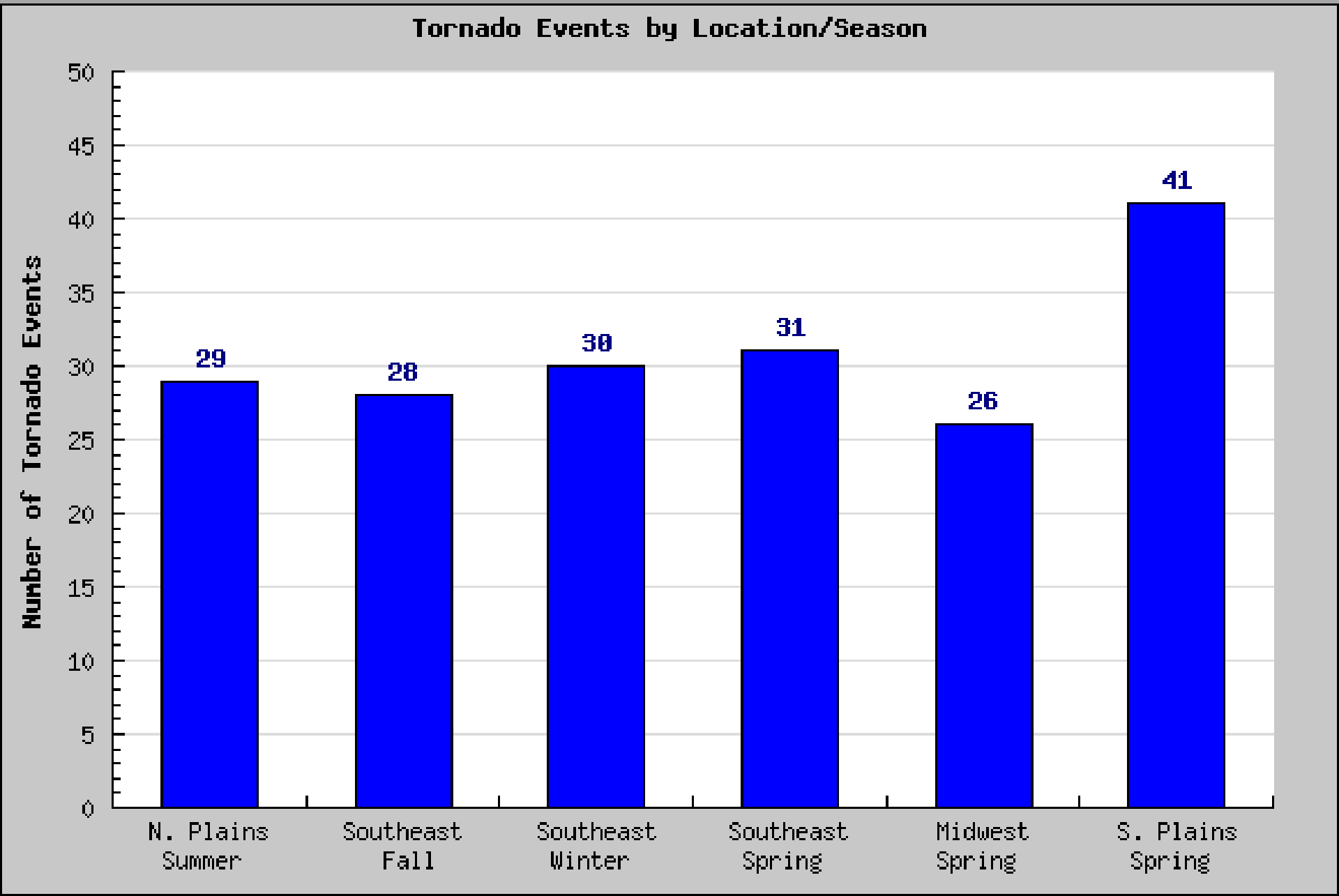
Tornado Distribution



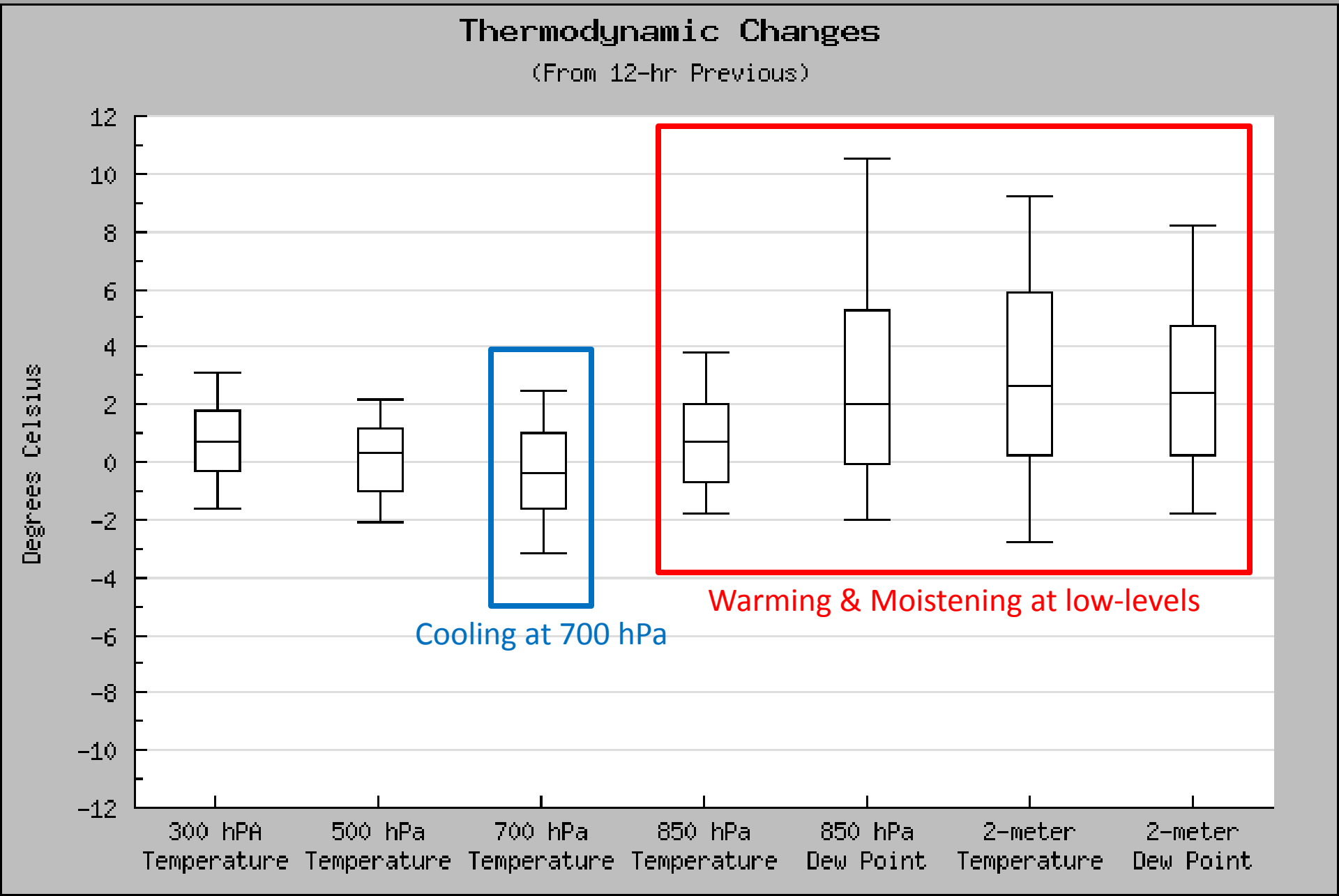
Geographic Regions:

Northern Plains (Yellow), Midwest (Blue), Northeast (Purple), Southeast (Green), Southern Plains (Red), West (Brown)

Tornado Distribution



Results – Key Parameters



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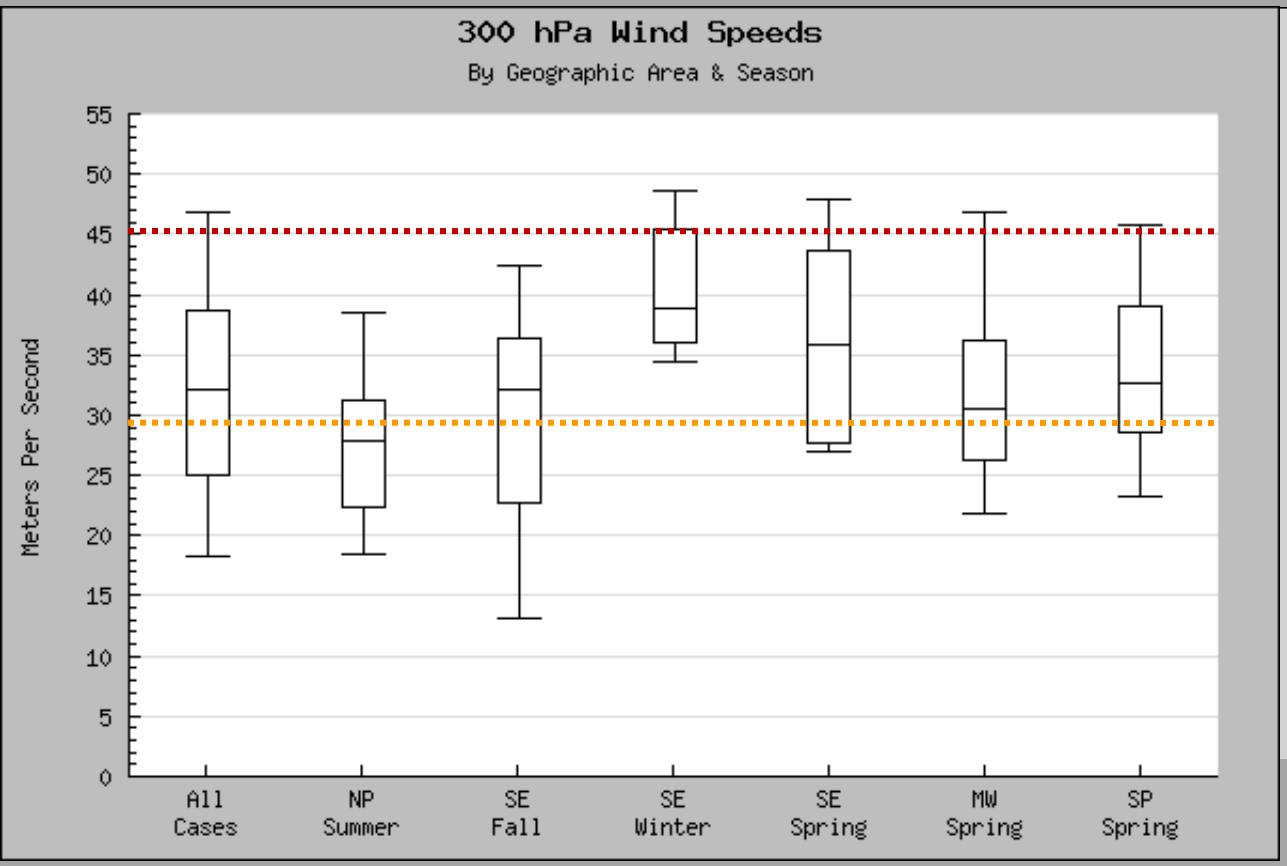
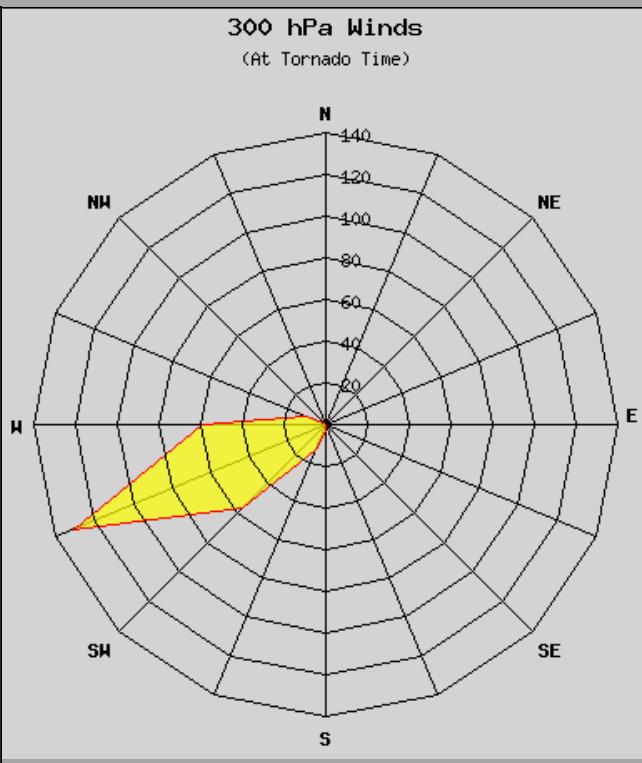




12-hour Wind Change

10 perc: 18 deg
Avg: -6 deg
90 perc: -28 deg

Miller Comparison

Strong Threshold

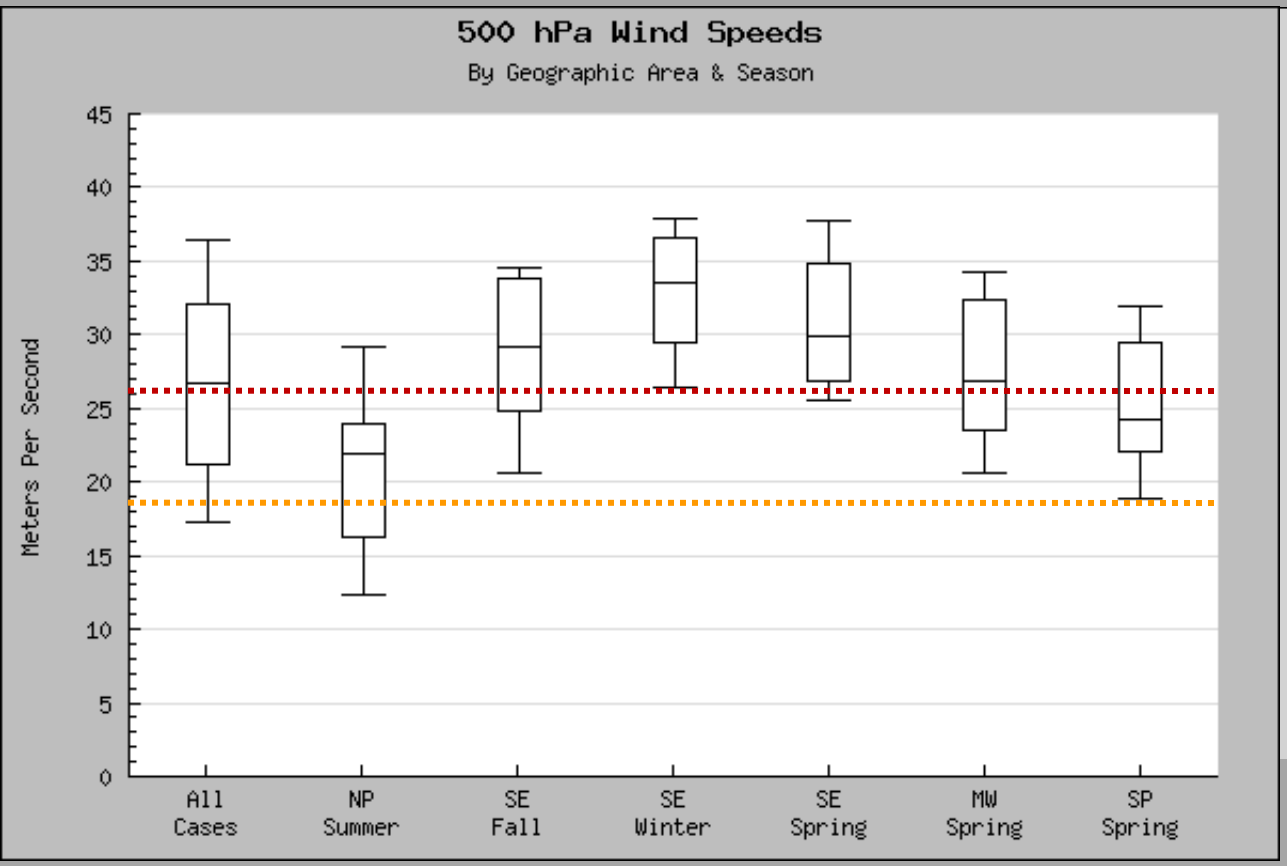
Moderate Threshold

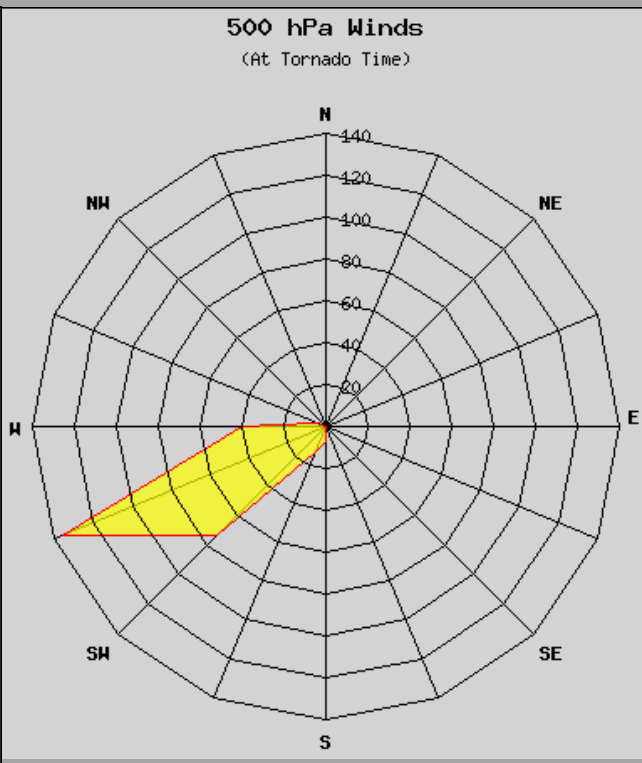
Wind Change

Negative → Backing w/ time

Positive → Veering w/ time

Results – Key Parameters





12-hour Wind Change

10 perc: 20 deg
Avg: -4 deg
90 perc: -25 deg

Miller Comparison

Strong Threshold

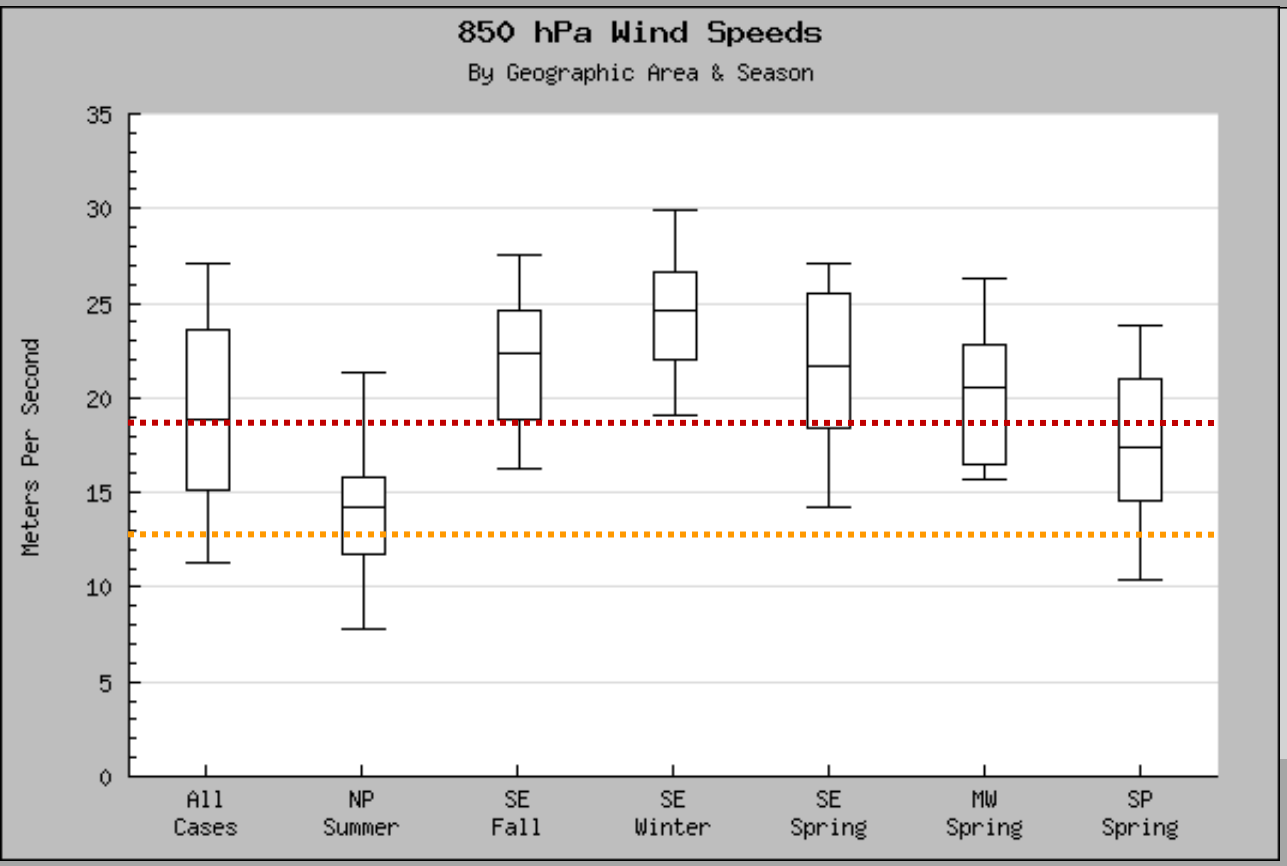
Moderate Threshold

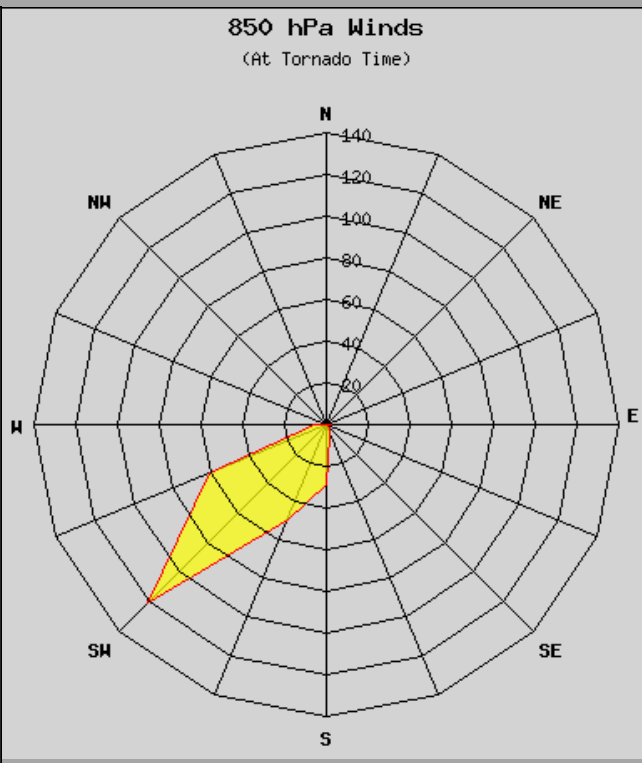
Wind Change

Negative → Backing w/ time

Positive → Veering w/ time

Results – Key Parameters





12-hour Wind Change

10 perc: 33 deg
Avg: -3 deg
90 perc: -46 deg

Miller Comparison

Strong Threshold

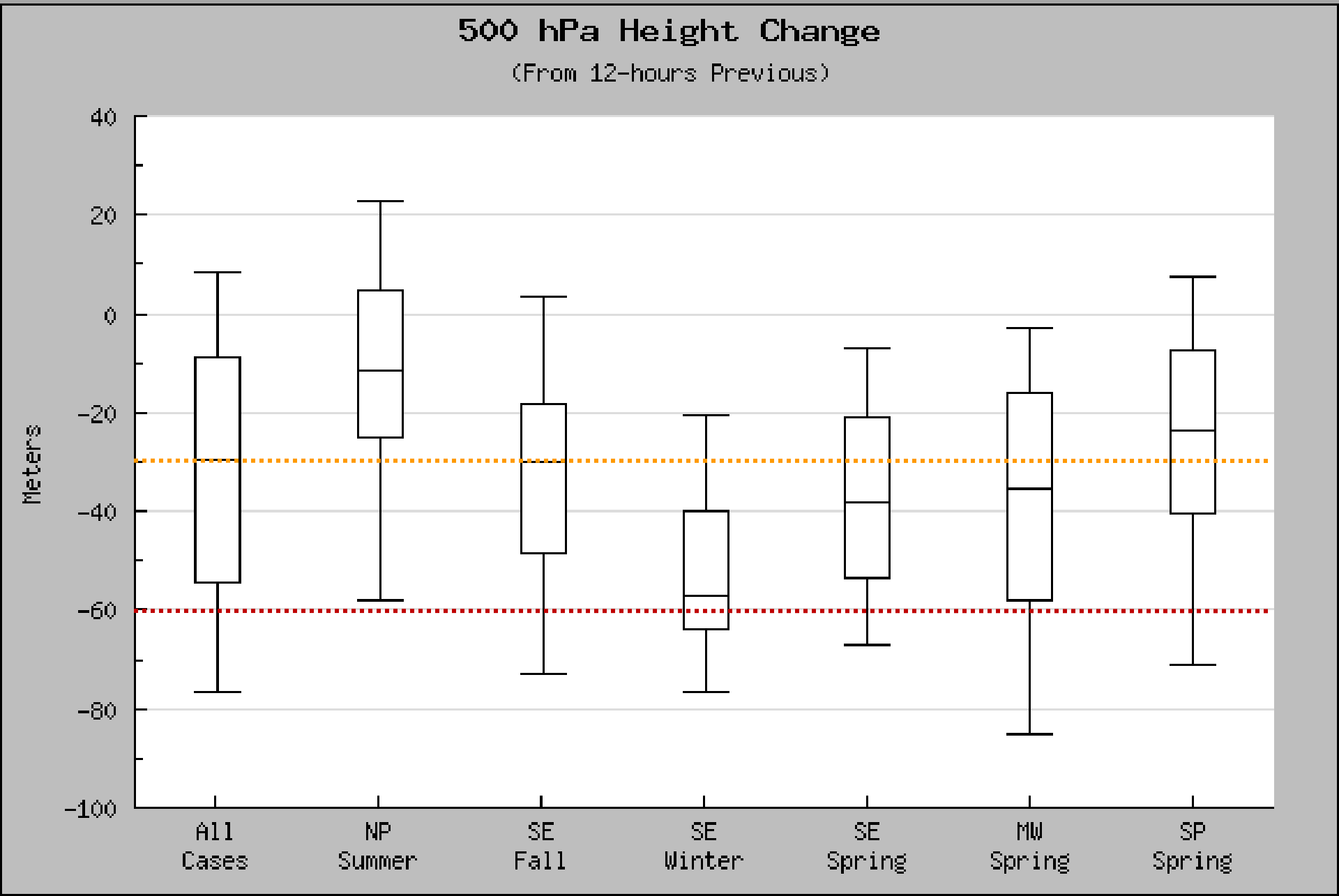
Moderate Threshold

Wind Change

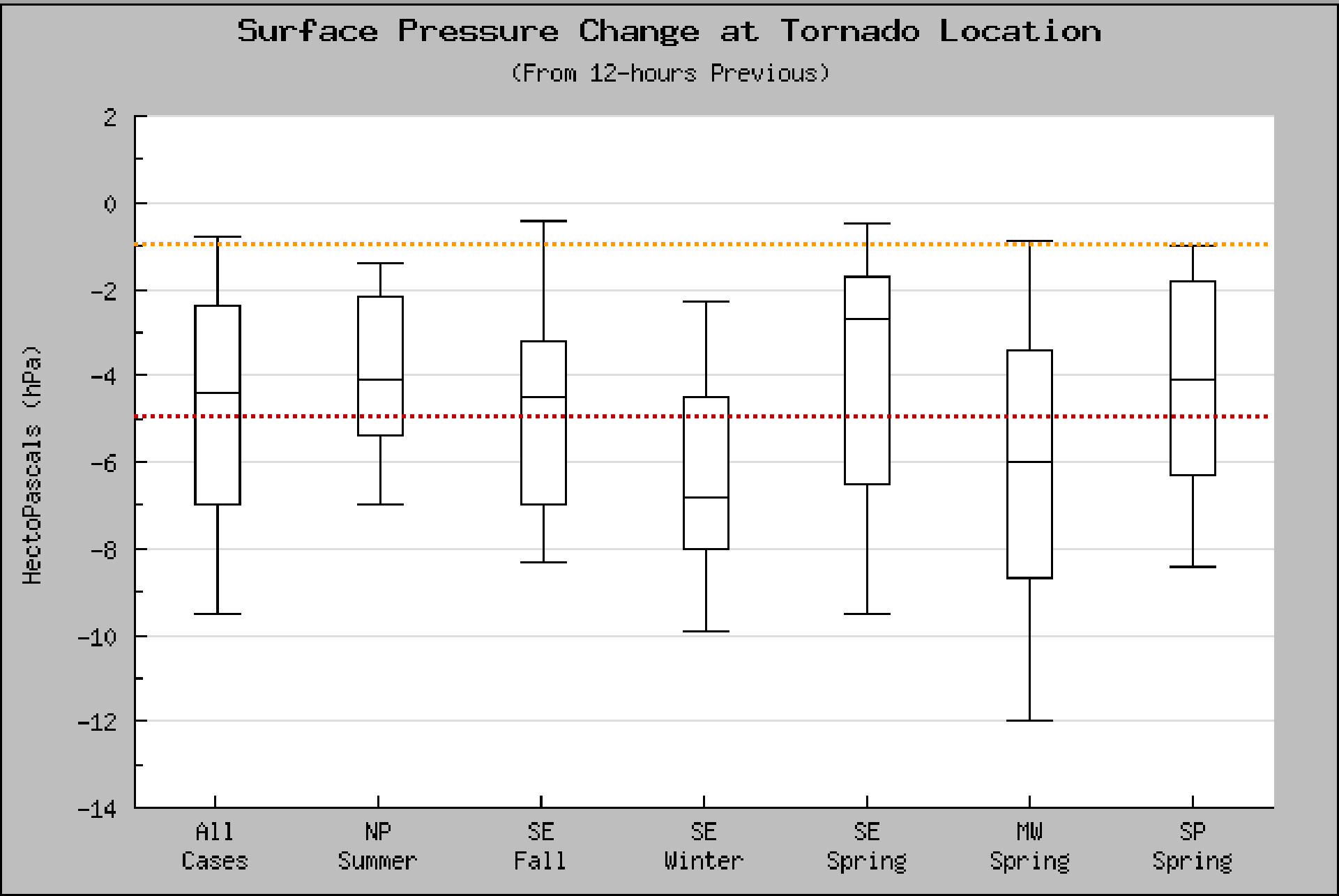
Negative → Backing w/ time

Positive → Veering w/ time

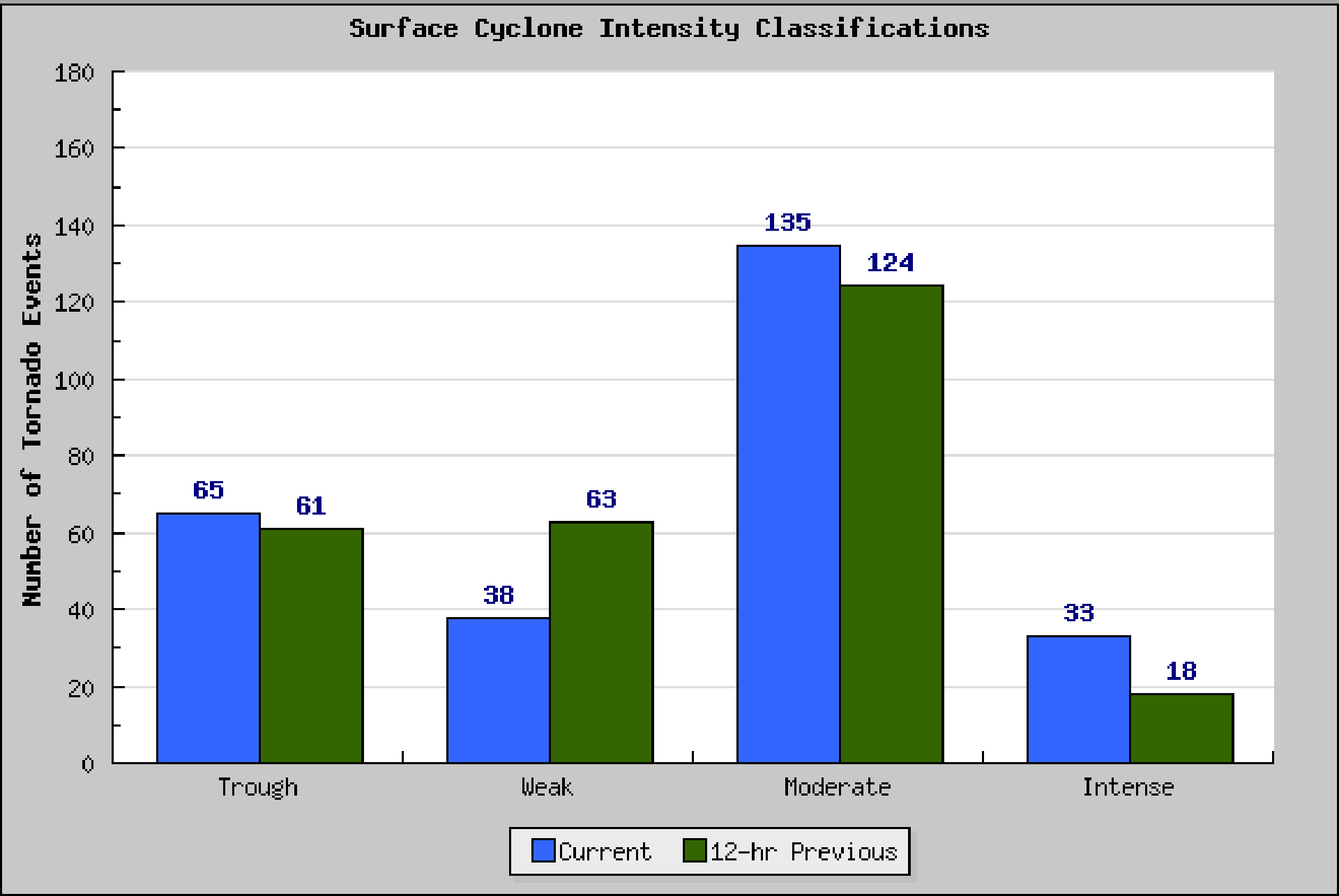
Results – Key Parameters



Results – Key Parameters



Results – Synoptic Patterns



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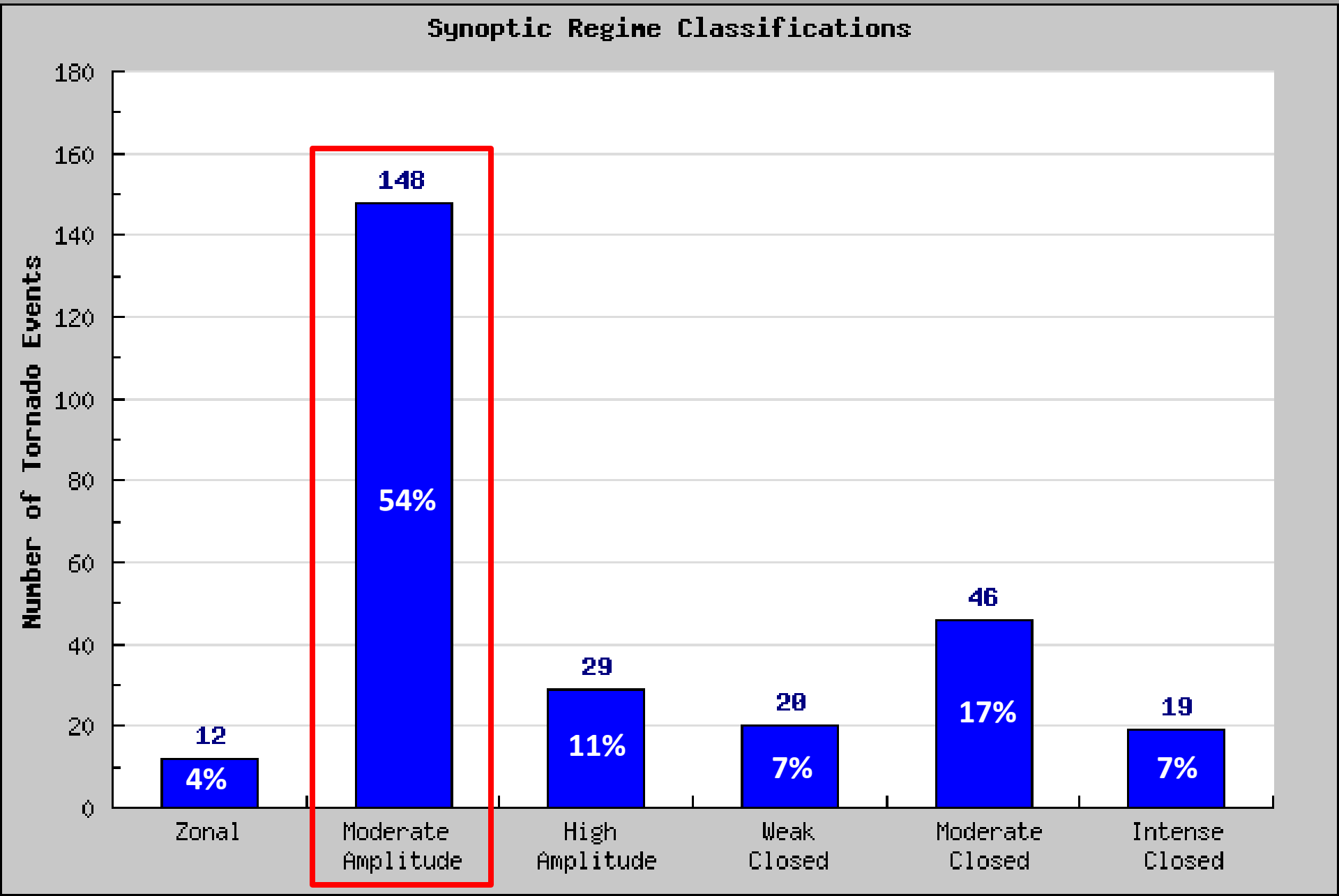

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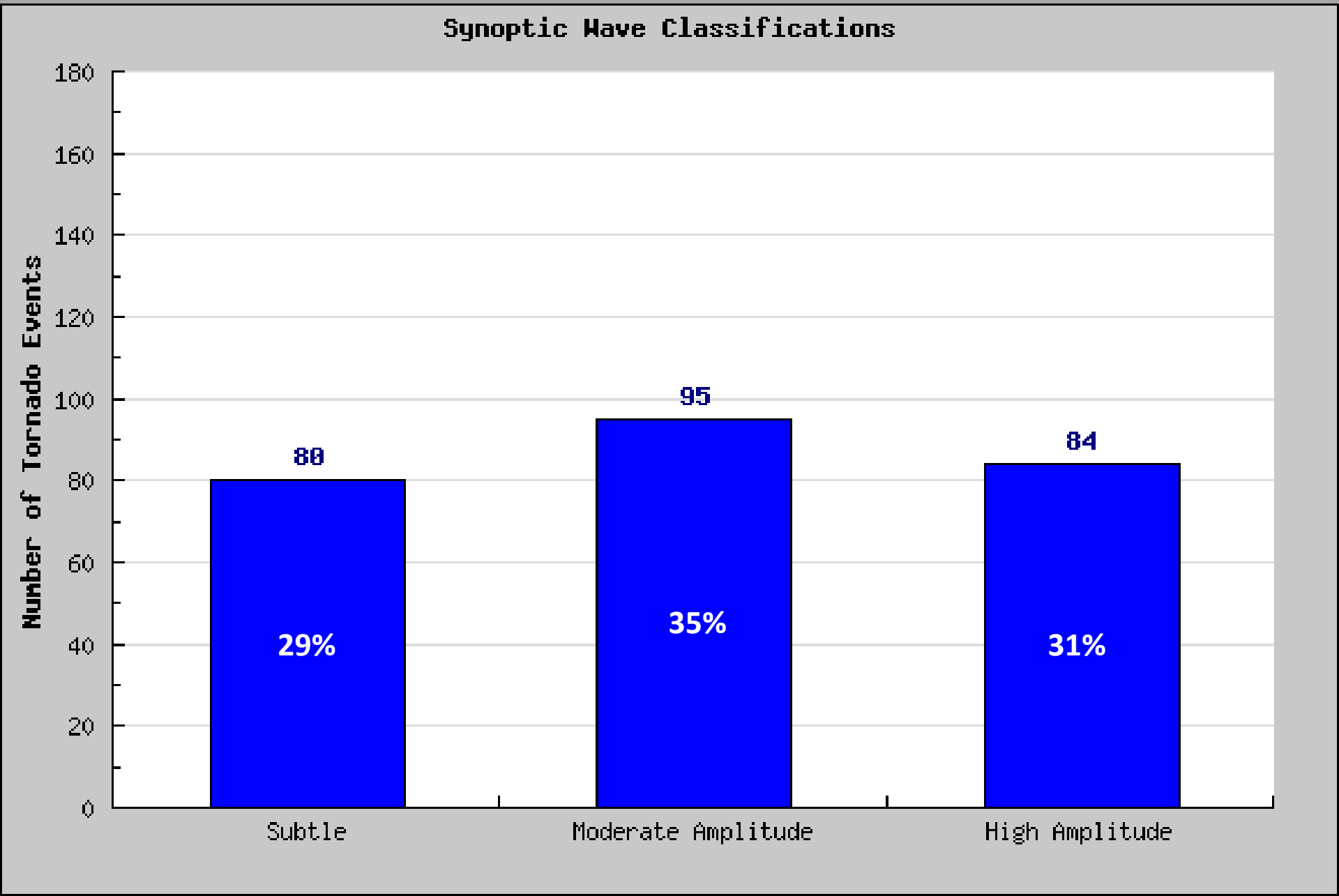

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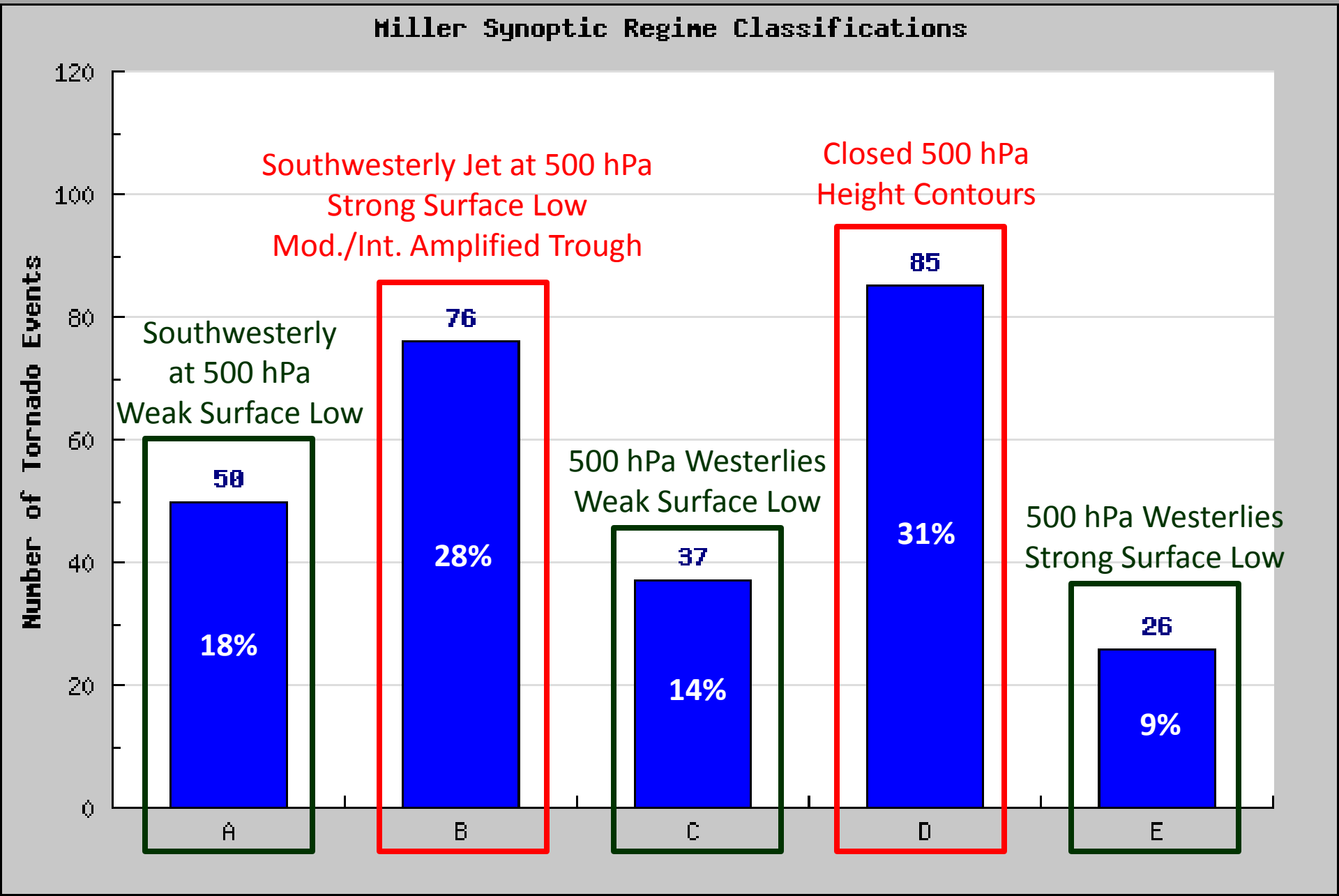

Conclusions

- Key parameters and synoptic patterns from Miller (1972) were largely replicated
  - Slight adjustments of parameters for significant tornadoes needed
  - Clarifications for upper level jet, and height falls may also be of use
  - Possibly separate pattern D (closed heights at 500 hPa) into more than one pattern to distinguish between extreme synoptic events and cold core low tornadoes
  - Always a few outlier patterns that do not fit directly into synoptic patterns (i.e. northwest flow events)

Further Research

- Addition of (E)F0 and (E)F1 tornadoes, and a comparison of the synoptic environment between ‘weak’ and ‘significant’ tornado events
- Viewing all severe weather events (hail/wind), and comparing synoptic environments between non-tornado producing events and the tornado producing events

Acknowledgements

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Questions?

Thank you…

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For the complete undergraduate thesis paper, visit
www.meteor.iastate.edu/~japrenti/thesis.html