A Climatology of Lower Stratospheric Fronts over North America

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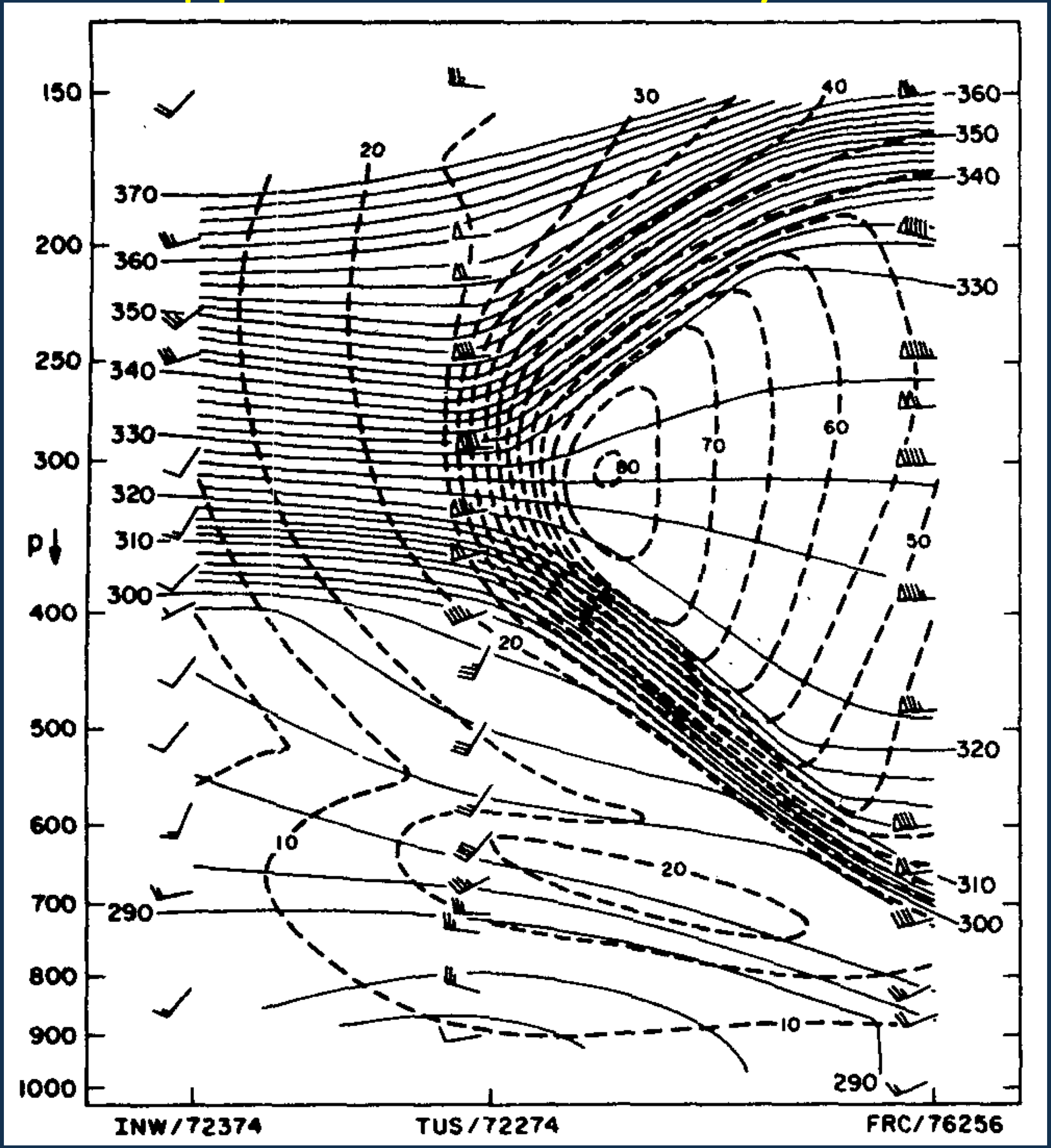
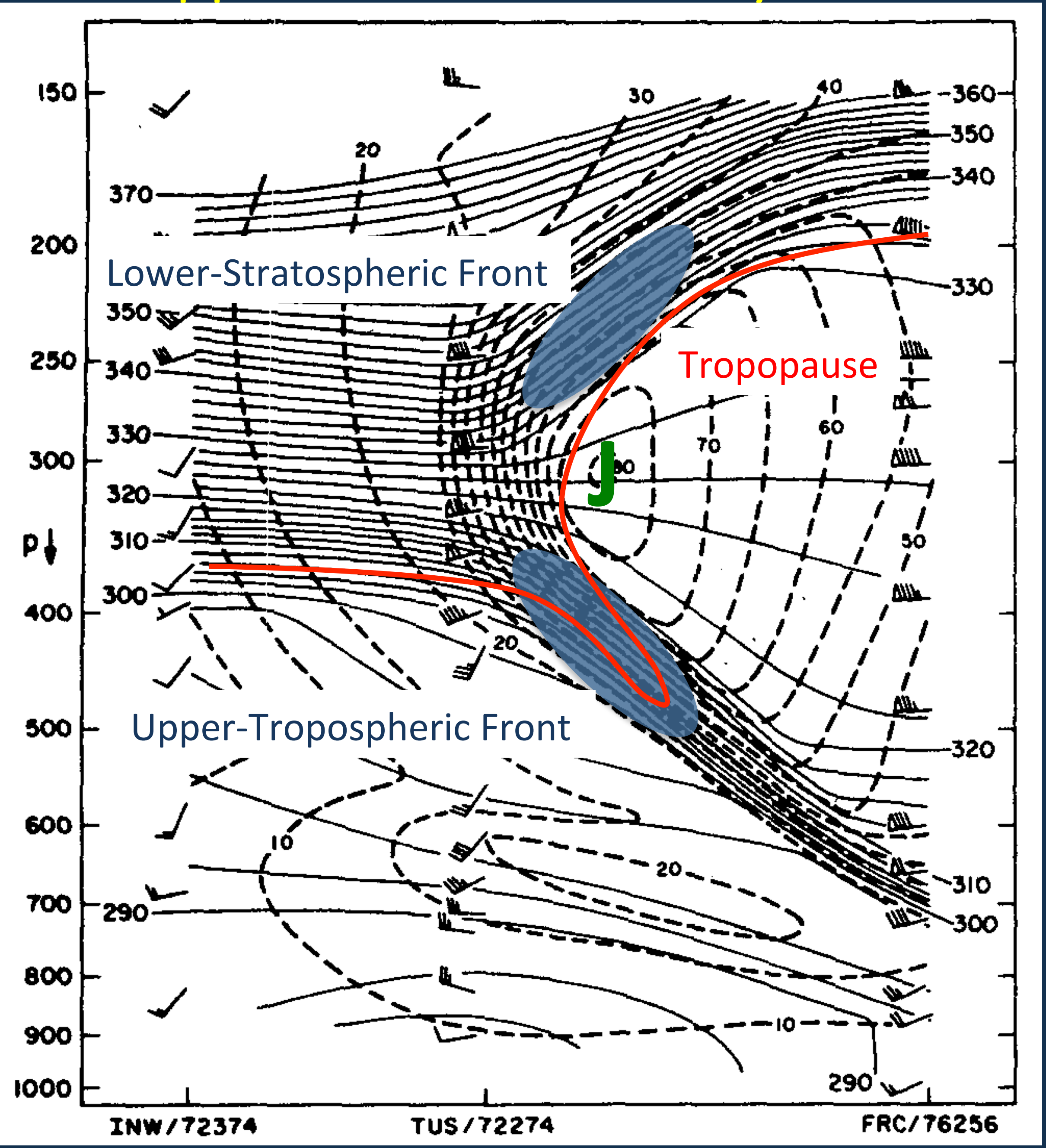
Upper-Level Jet-Front System



Shapiro 1981

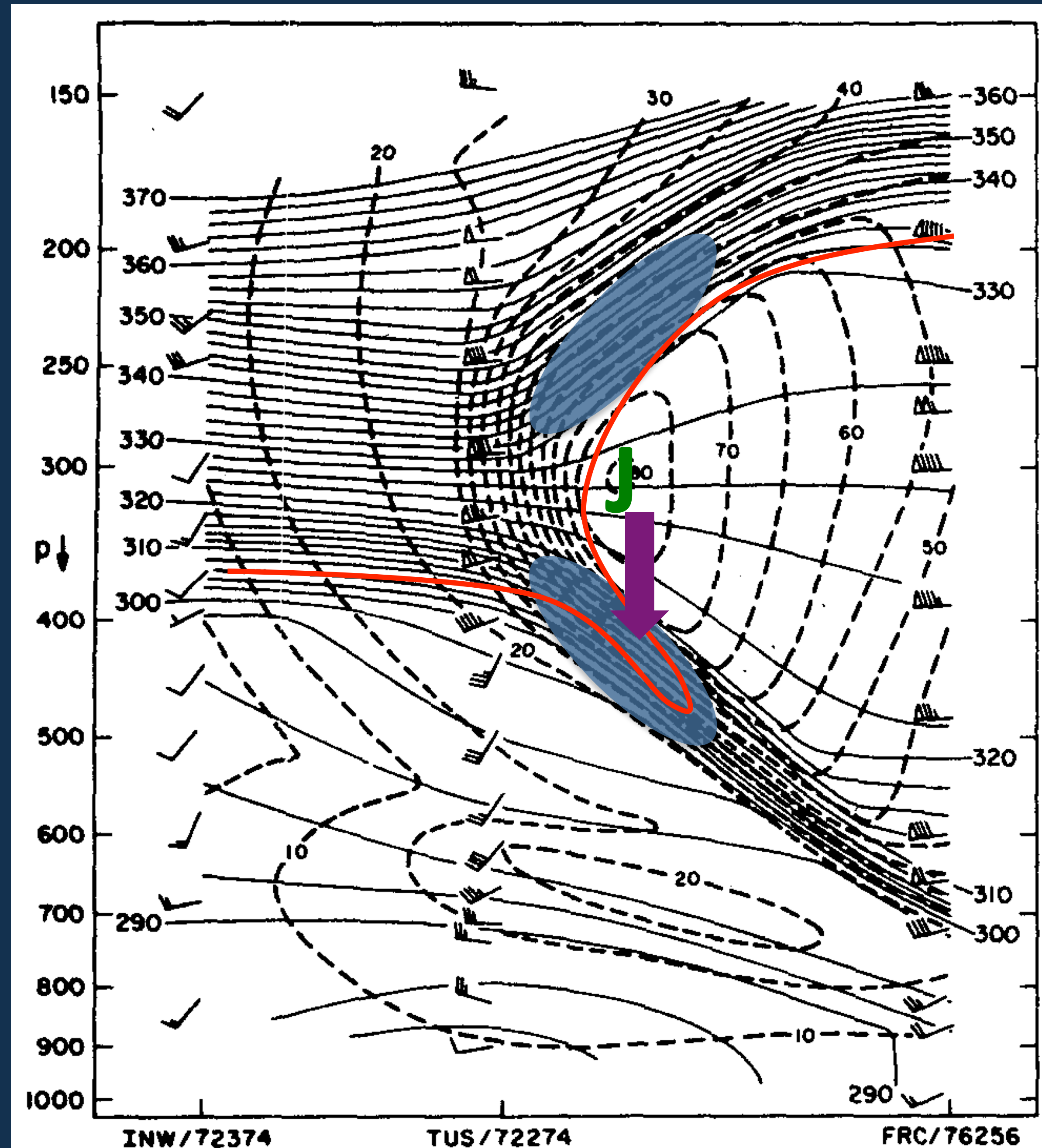
Upper-Level Jet-Front System



Shapiro 1981

Background and Motivation

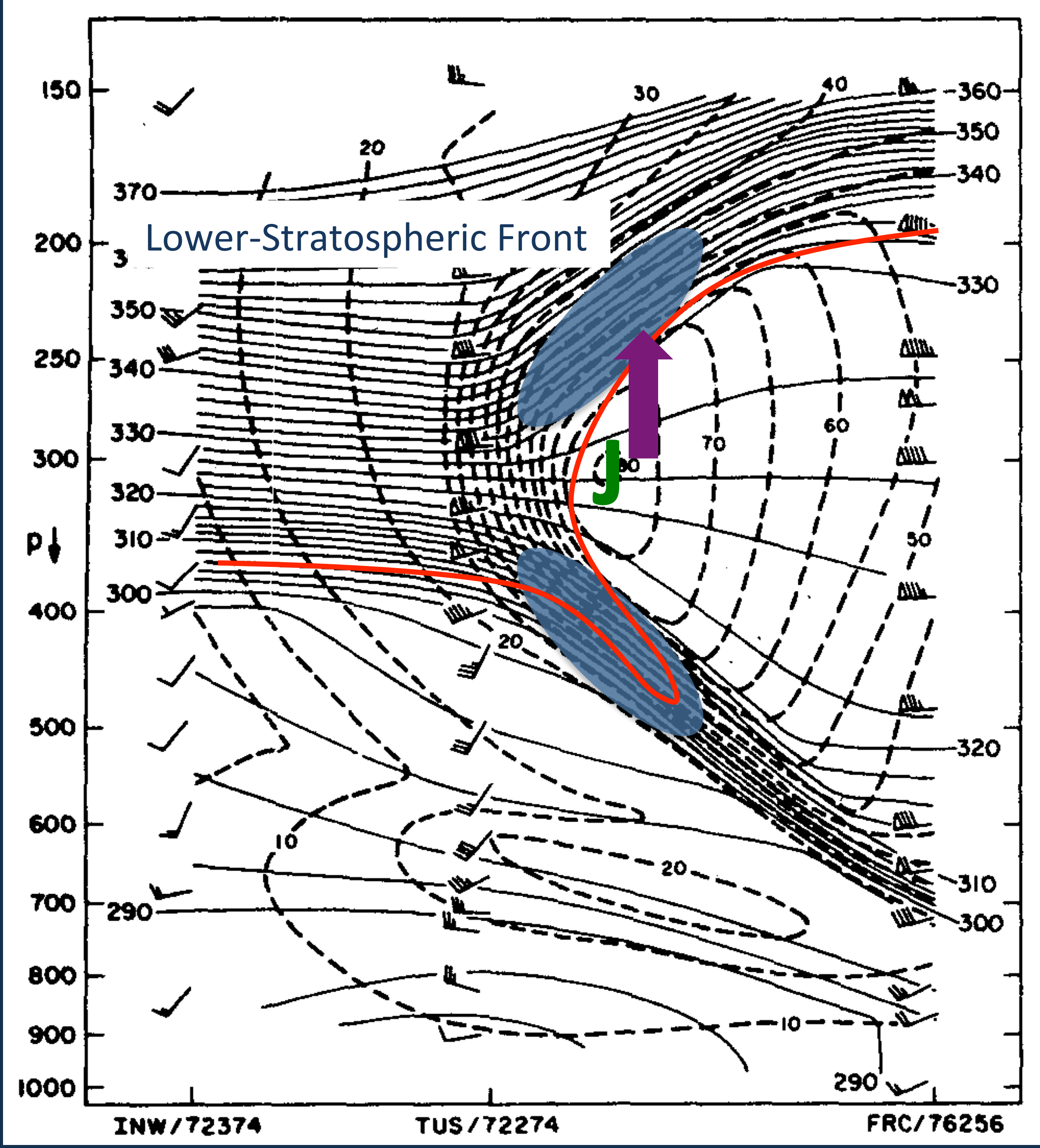
- Upper-Tropospheric Fronts (Shapiro 1981; Keyser and Shapiro 1985):
  - develop via tilting (descent)
  - High PV air from the stratosphere can enter the troposphere
- This positive PV anomaly can act as an upper-level precursor to surface cyclogenesis events (Lackmann et al. 1997)



Shapiro 1981

Background and Motivation

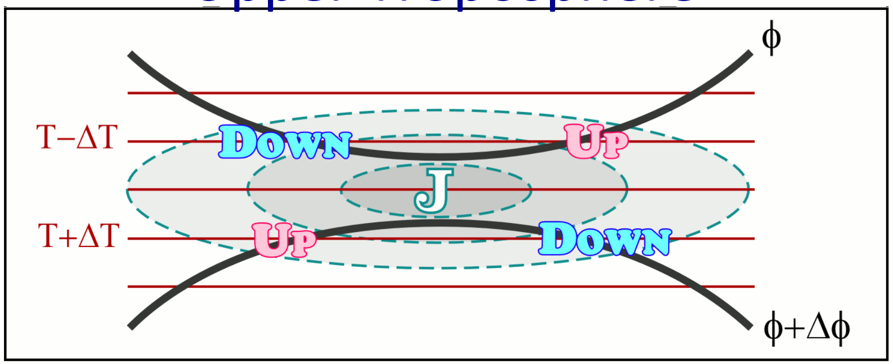
- Lower-Stratospheric Fronts develop via tilting:
  - ascent
- Little research has been done on lower stratospheric fronts
- Without a clear picture of the life cycle of LSFs we do not have an accurate understanding of the entire Upper Level Jet-Front (ULJF) System



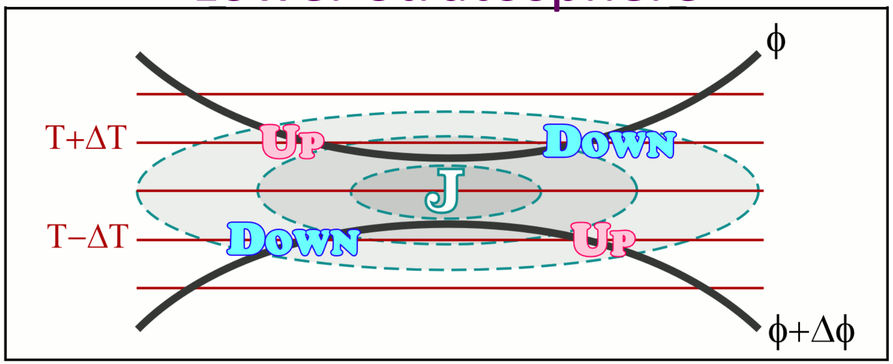
Shapiro 1981

Jet Circulations

Below the jet core:
Upper Troposphere



Above the jet core:
Lower Stratosphere

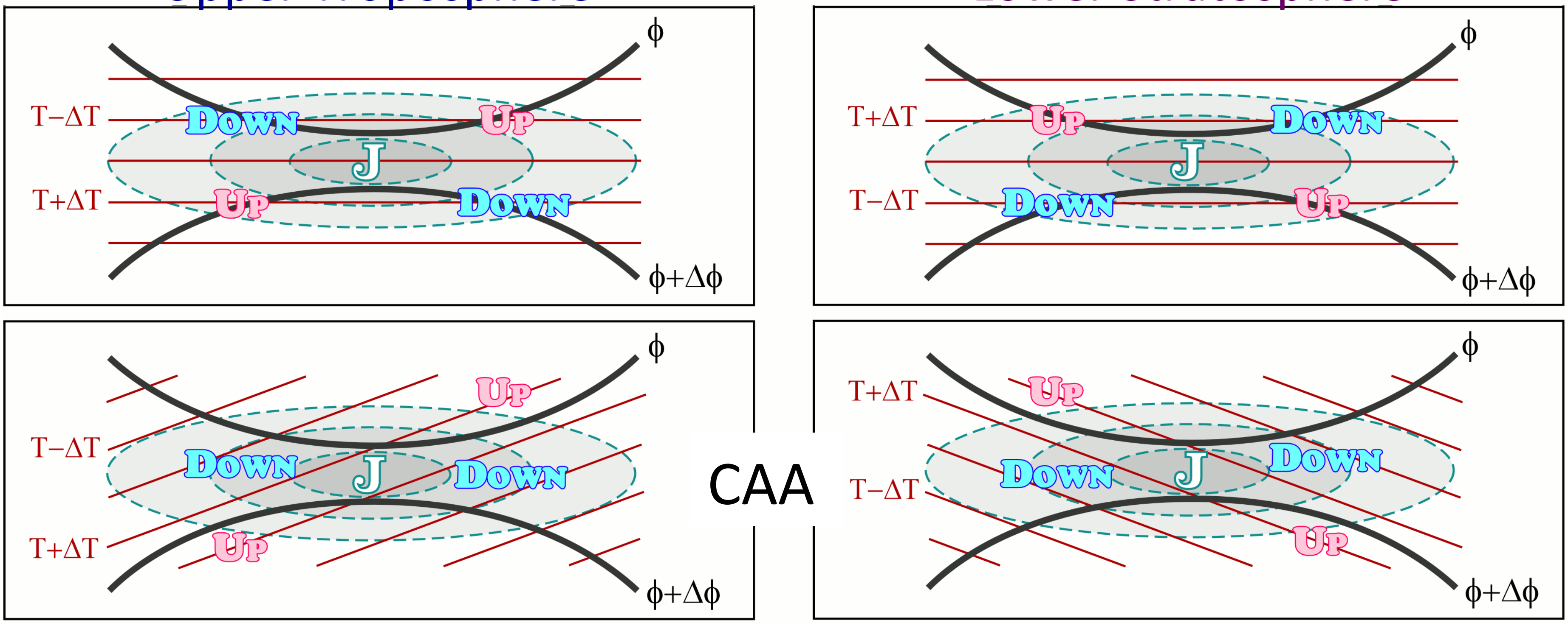


Lang and Martin (2012)

Jet Circulations

Below the jet core: Upper Troposphere

Above the jet core: Lower Stratosphere

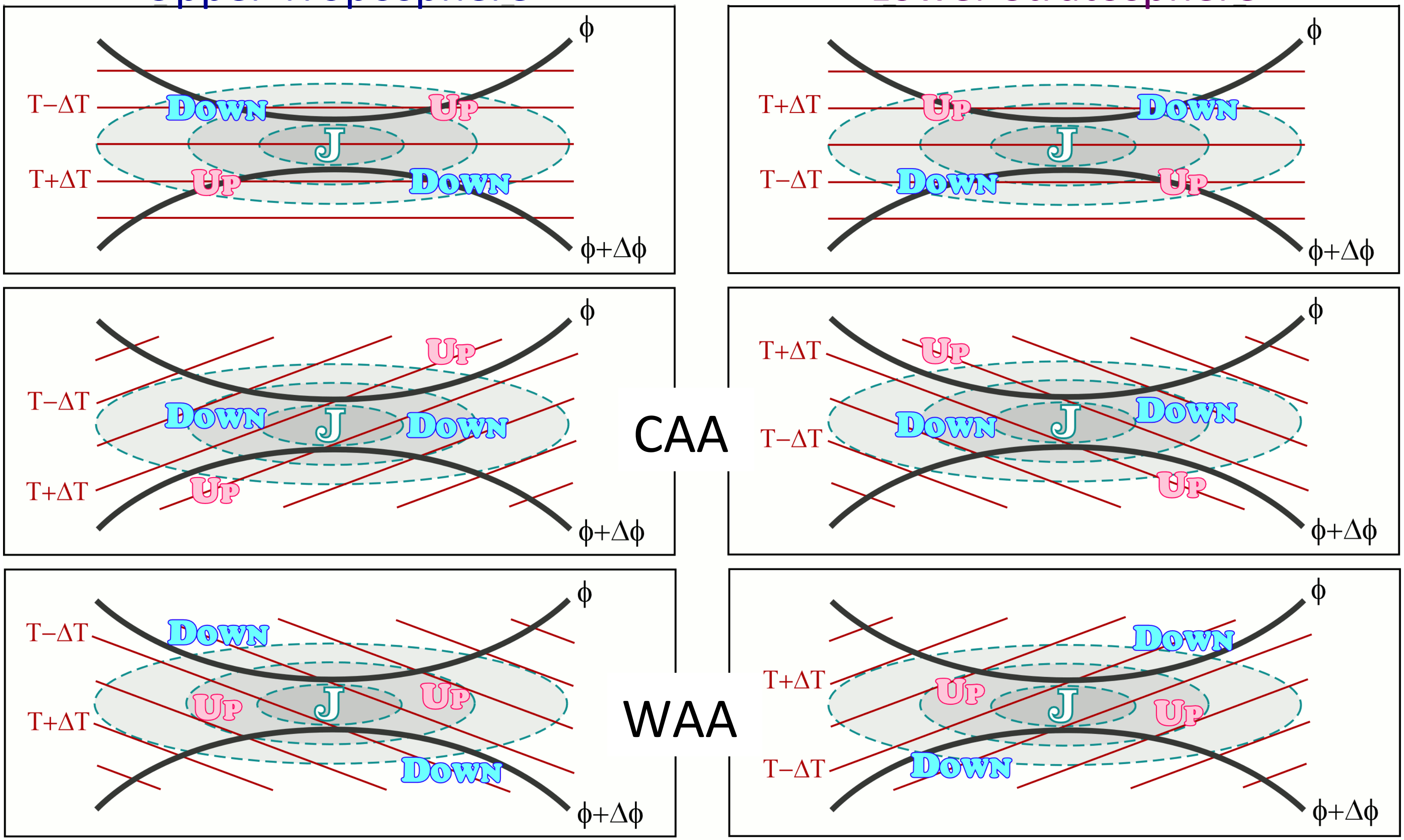


Lang and Martin (2012)

Jet Circulations

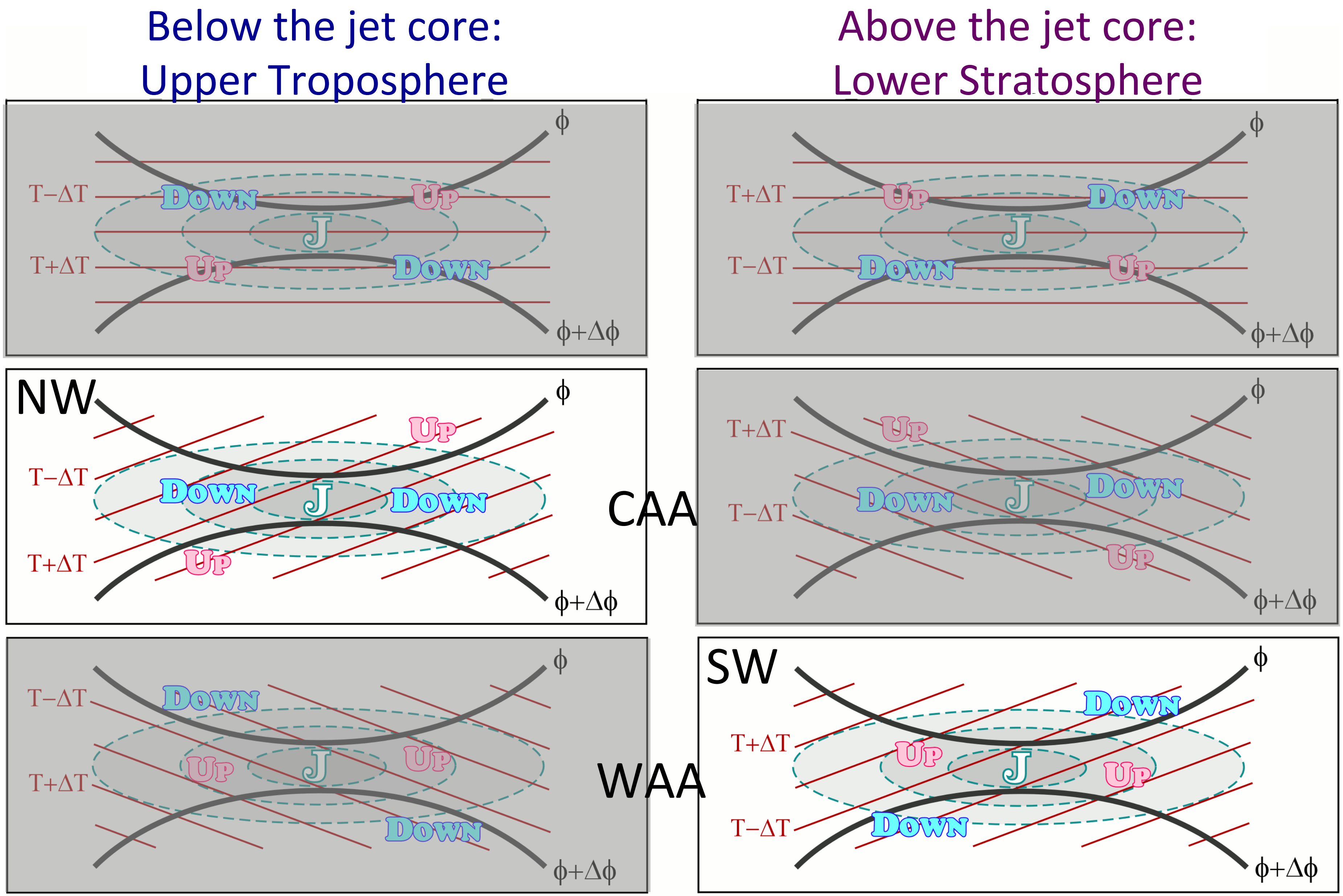
Below the jet core: Upper Troposphere

Above the jet core: Lower Stratosphere



Lang and Martin (2012)

Jet Circulations

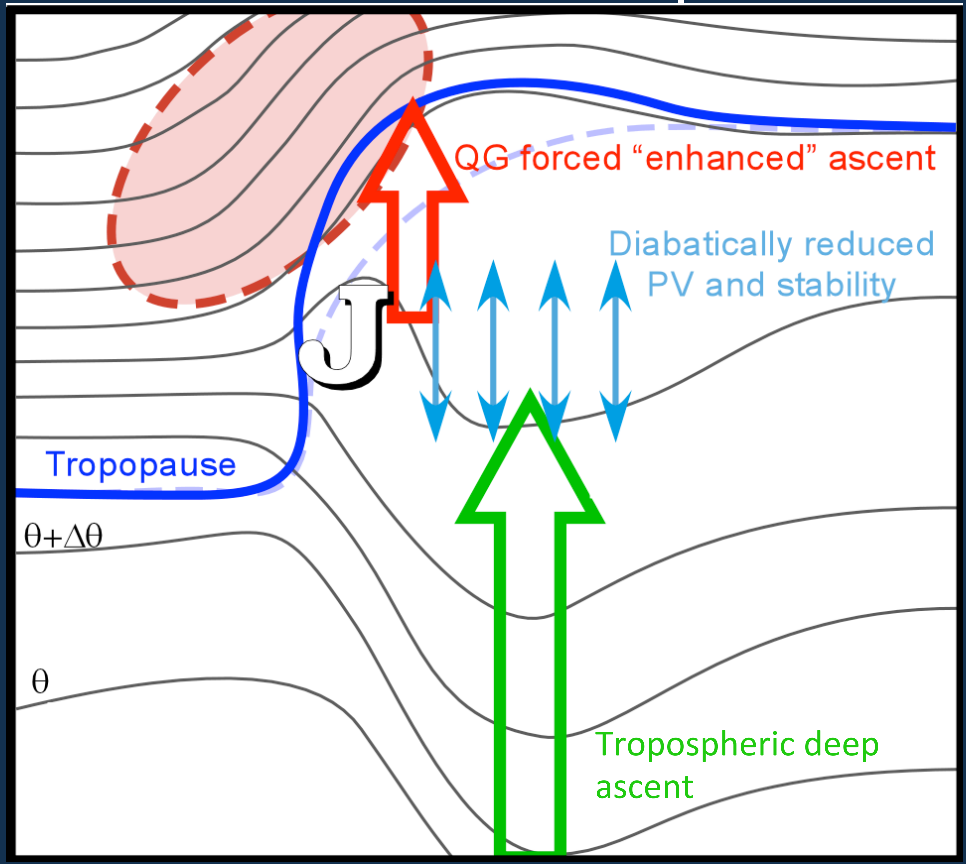


Lang and Martin (2012)

Previous Research

Lang and Martin 2013

Conceptual model of LSF development in SW flow



Isentropes: thin black lines; **Dynamic tropopause**: blue line; **Geostrophic Warm Air Advection**: Shaded region; **Ascent:** arrows; **Jet:** J

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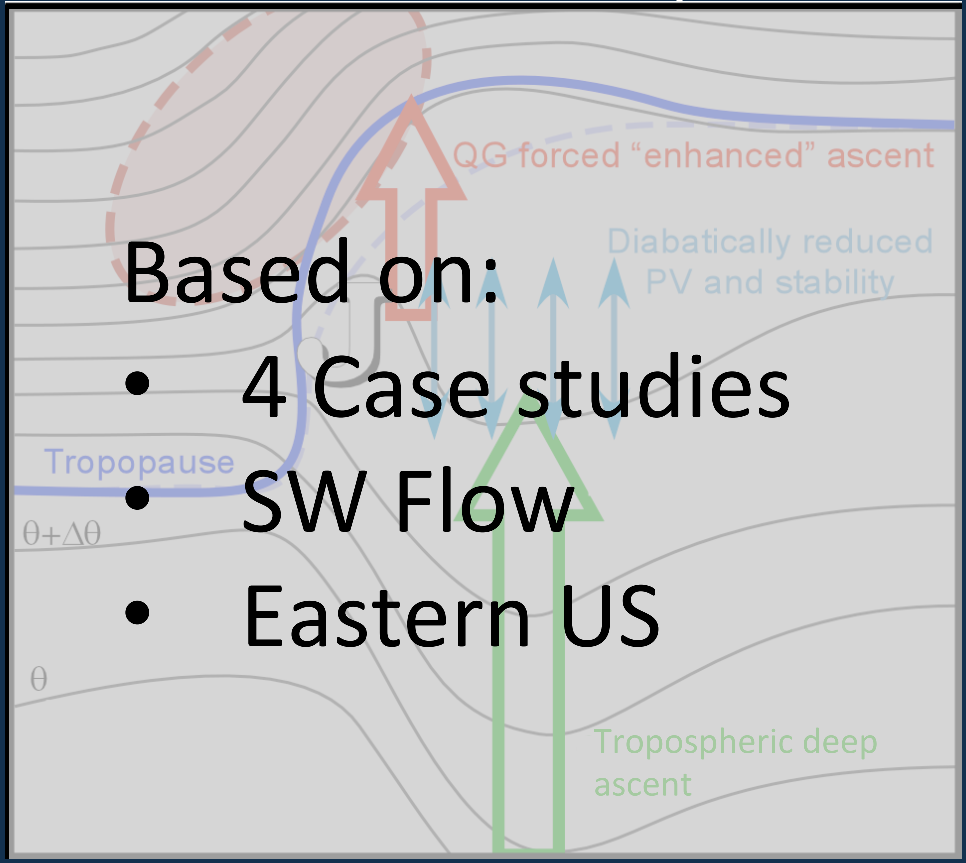

Based on:

- 4 Case studies
- SW Flow
- Eastern US

Isentropes: thin black lines; **Dynamic tropopause**: blue line; **Geostrophic Warm Air Advection**: Shaded region; **Ascent:** arrows; **Jet:** J

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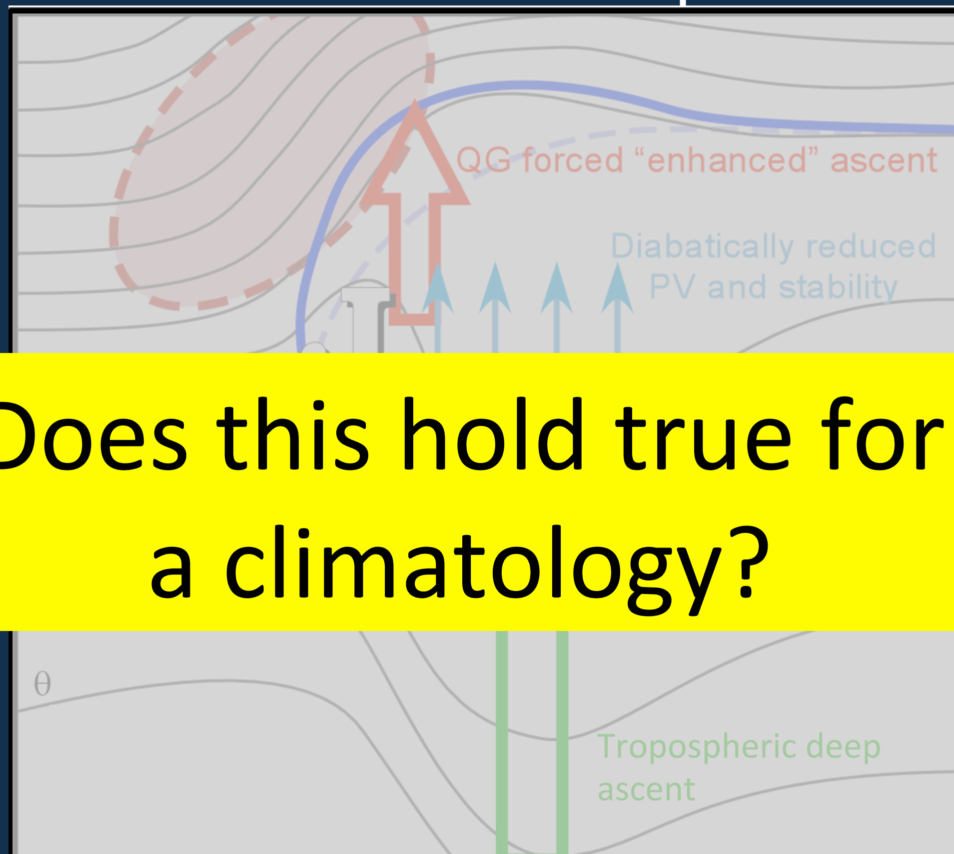


Does this hold true for a climatology?

Isentropes: thin black lines; **Dynamic tropopause**: blue line; **Geostrophic Warm Air Advection**: Shaded region; **Ascent:** arrows; **Jet:** J

Criteria for Climatology

Occur over North America

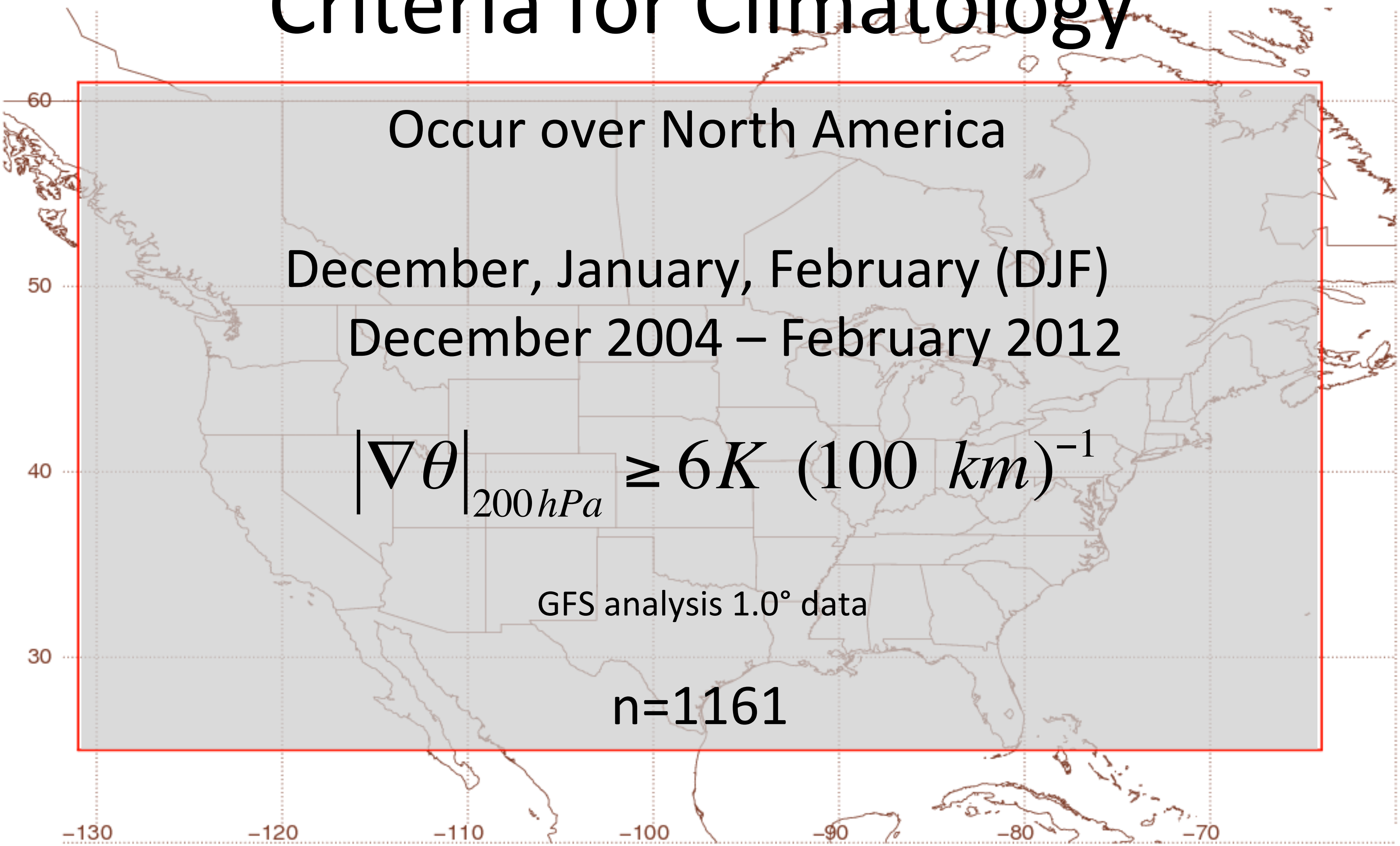
December, January, February (DJF)

December 2004 – February 2012

$$\left|\nabla \theta\right|_{200\,hPa} \geq 6K\ \ (100\ \ km)^{-1}$$

GFS analysis 1.0° data

n=1161

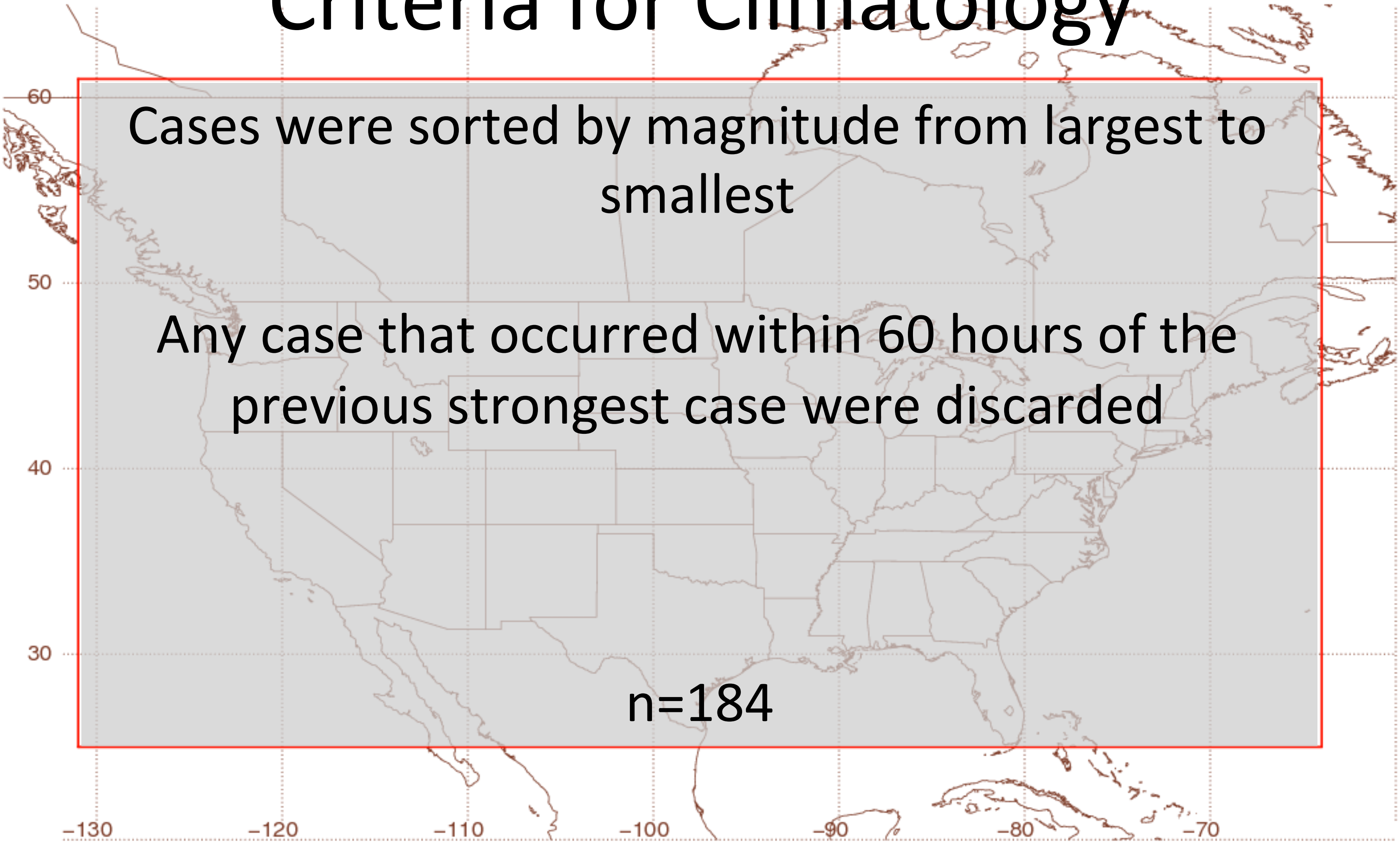


Criteria for Climatology

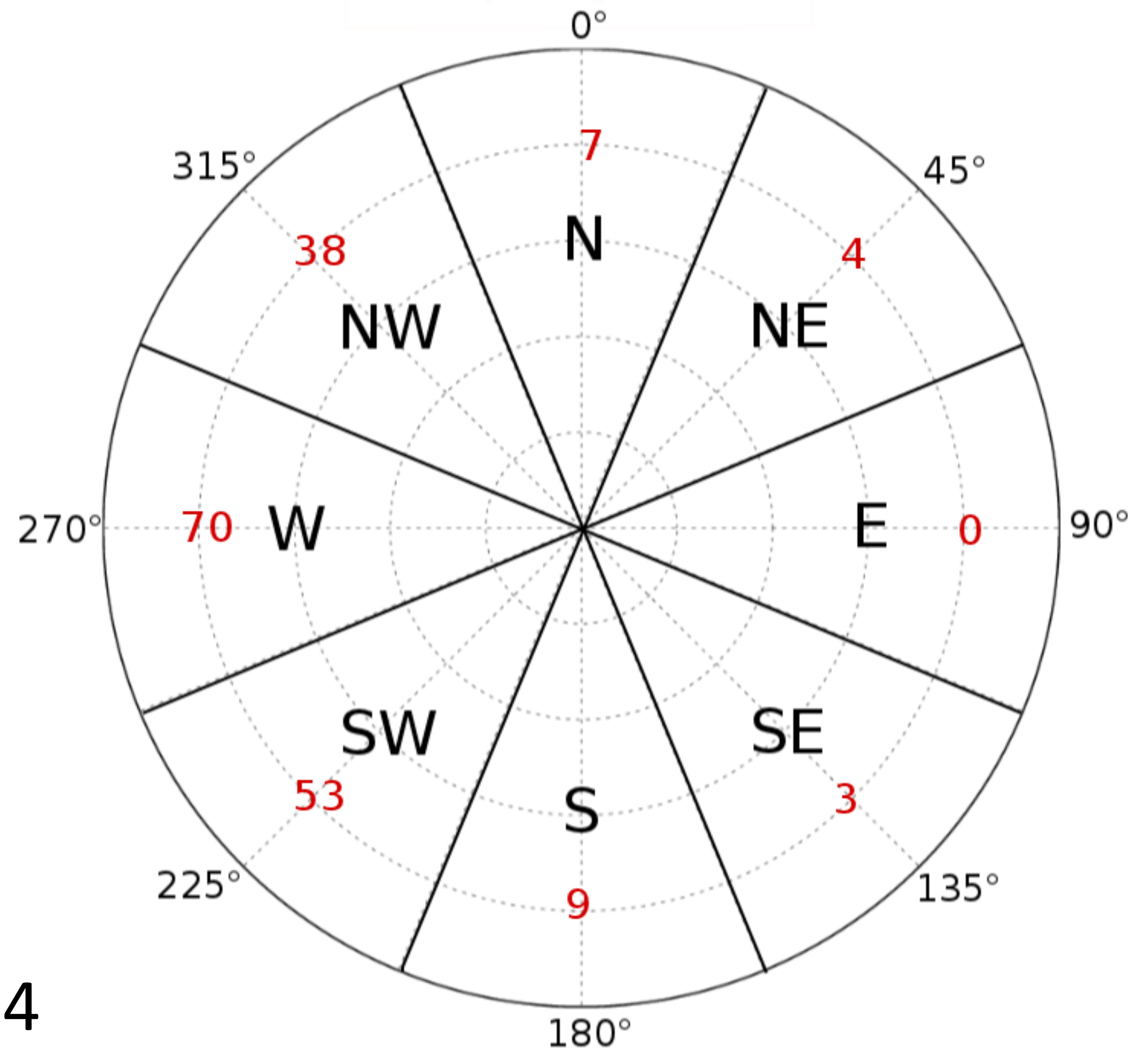
Cases were sorted by magnitude from largest to smallest

Any case that occurred within 60 hours of the previous strongest case were discarded

n=184



Cases were sorted by Wind Direction



n=184

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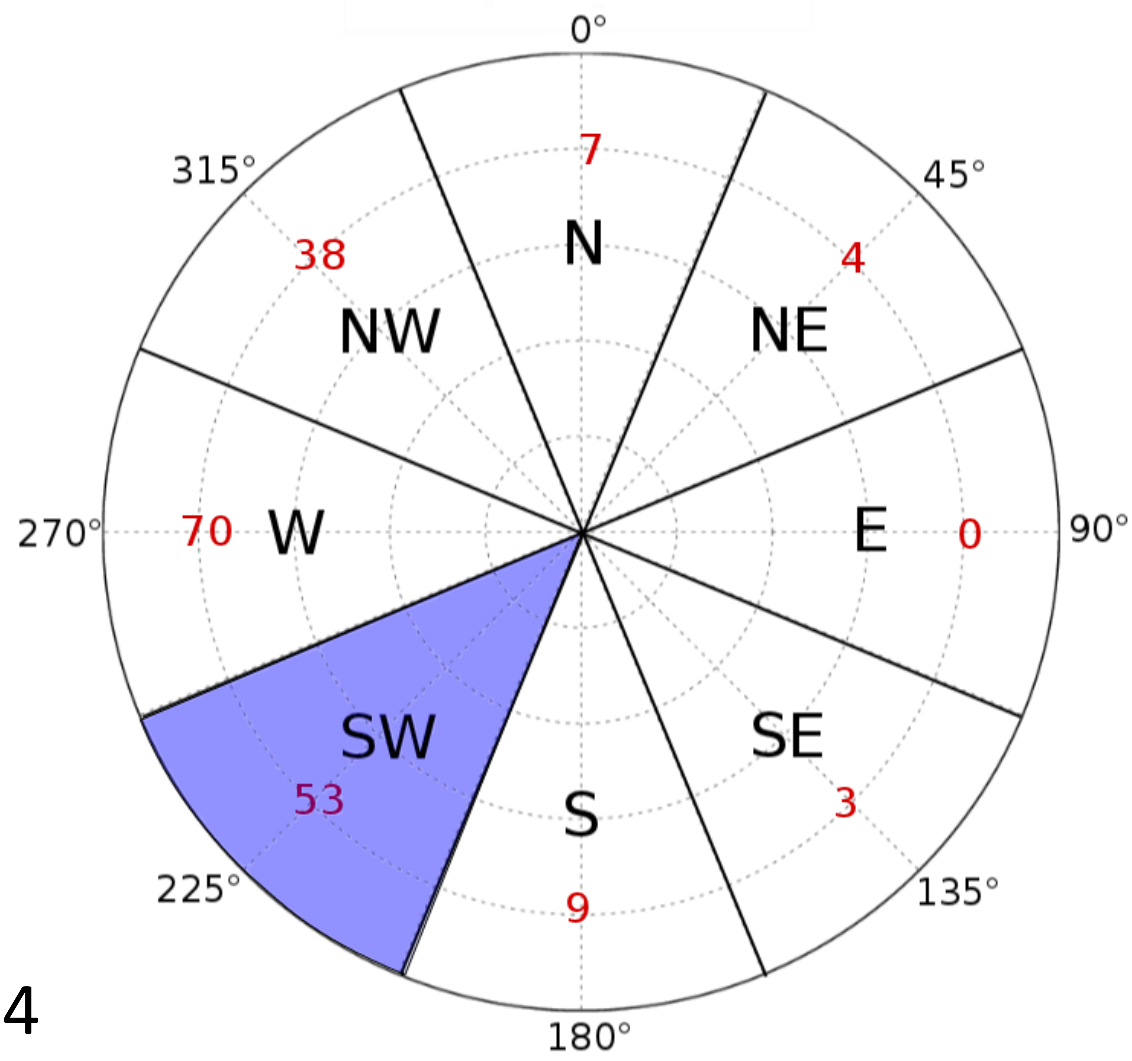
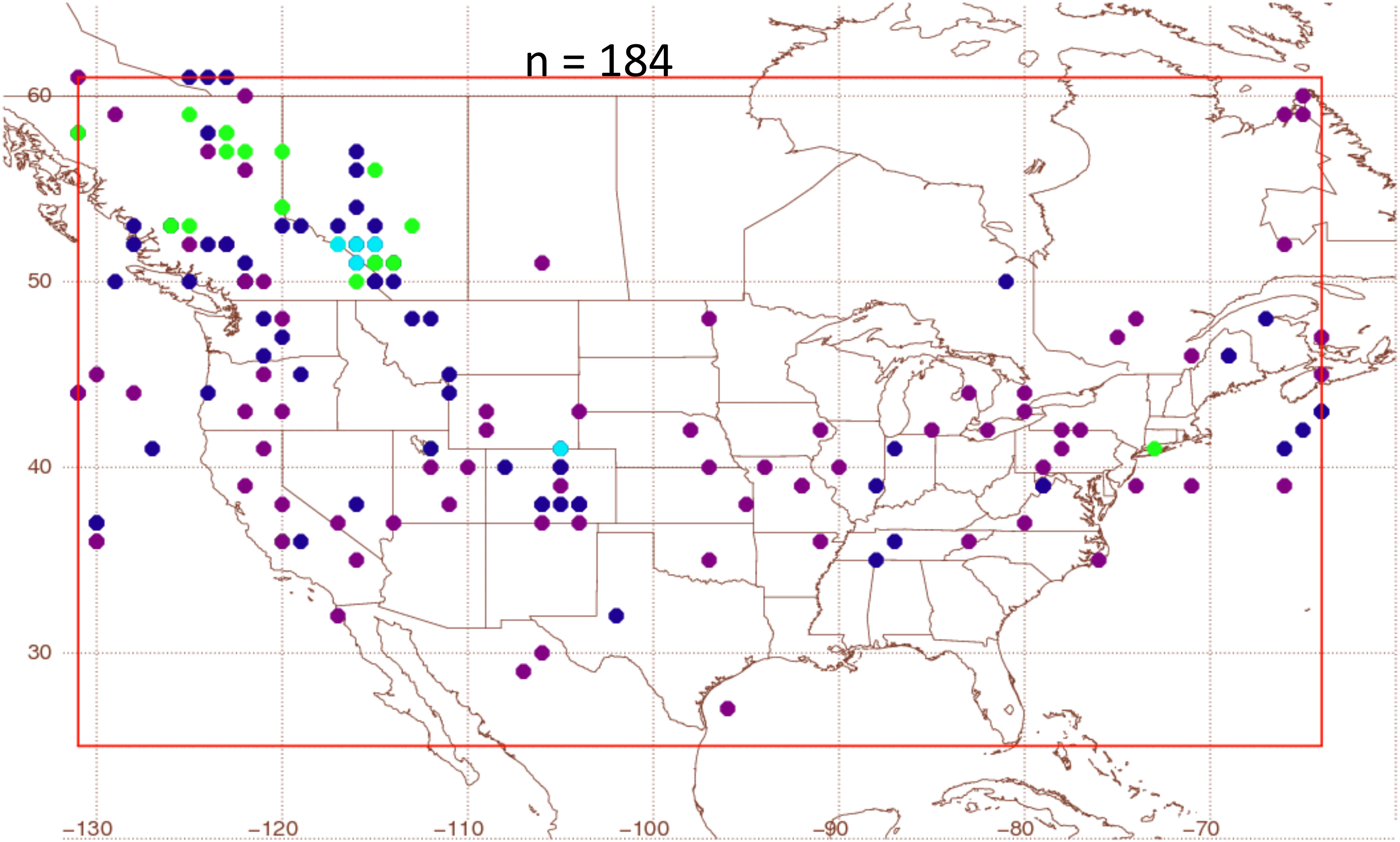


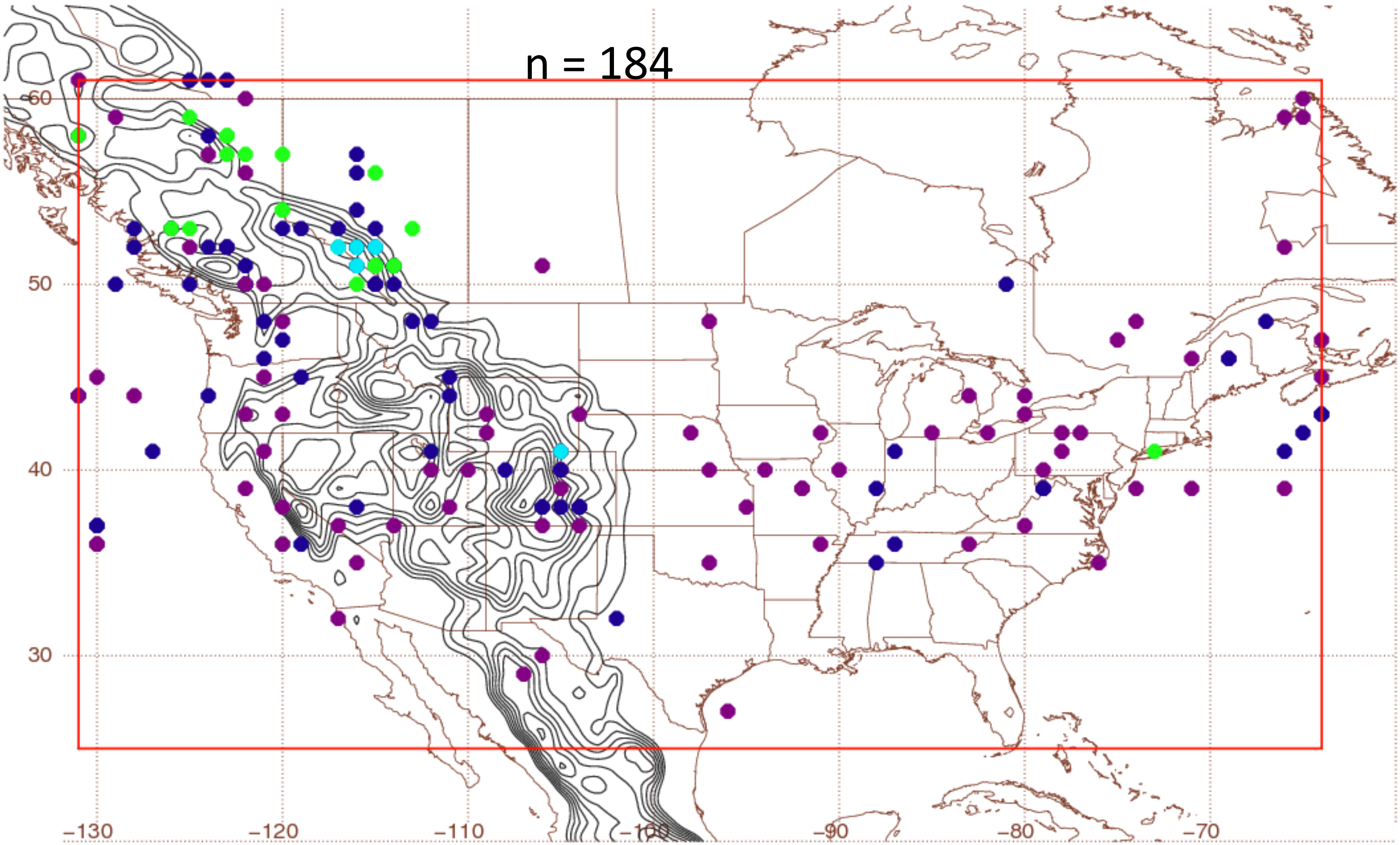
n=184

Location of all cases color coded by magnitude



≥ 15K (100km)$^{-1}$
≥ 12K (100km)$^{-1}$
≥ 9K (100km)$^{-1}$
≥ 6K (100km)$^{-1}$

Location of all cases color coded by magnitude



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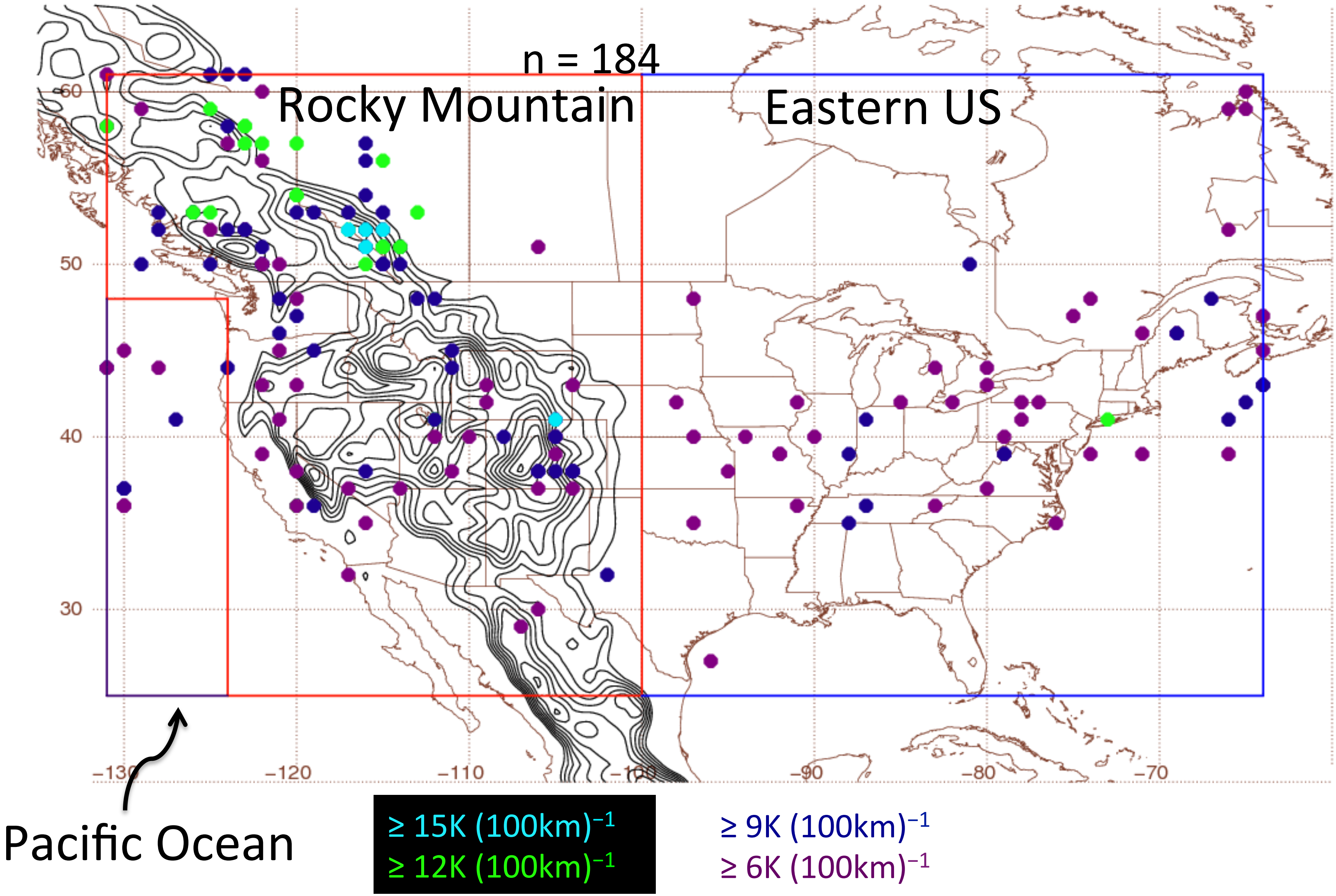

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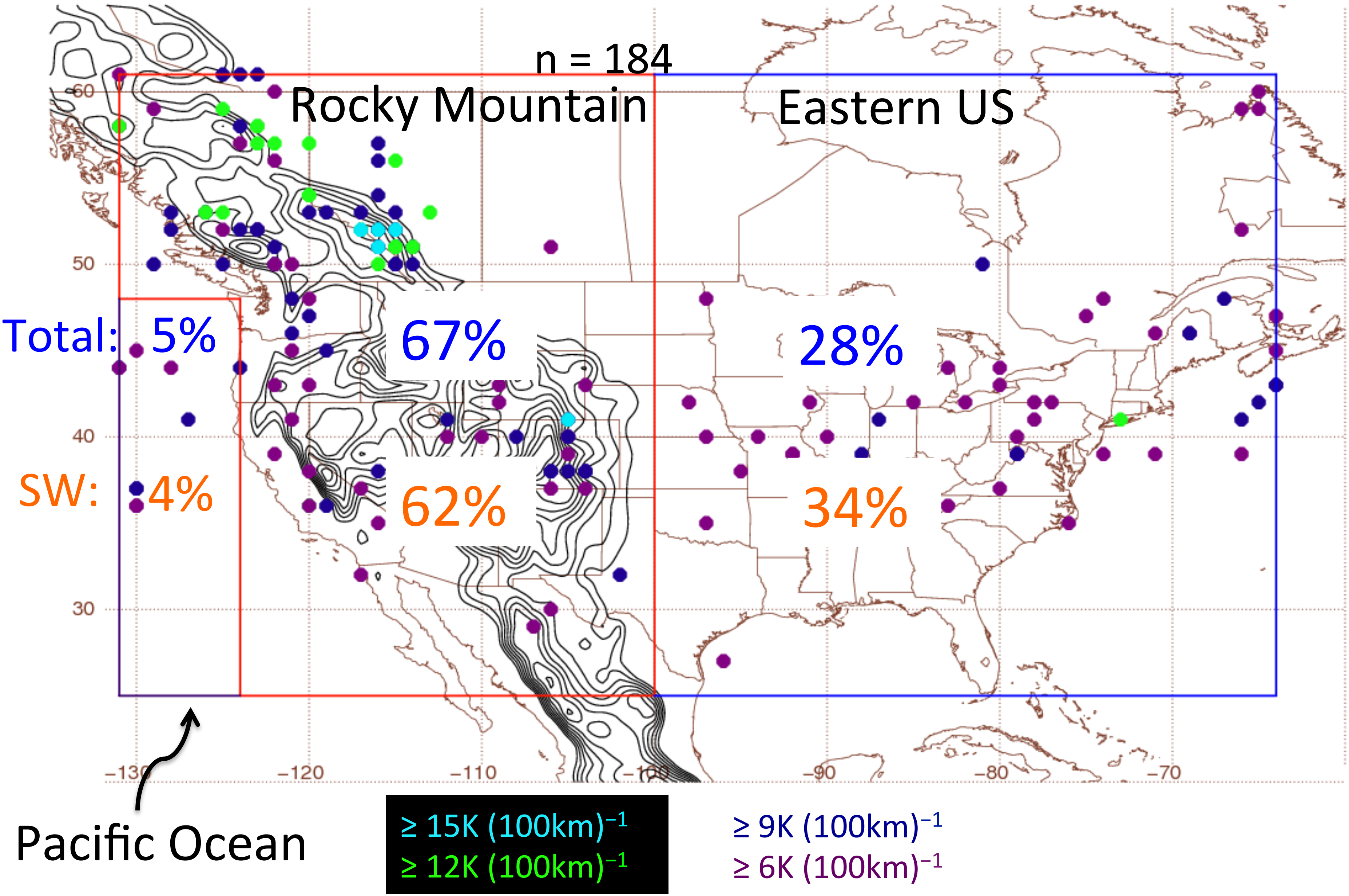
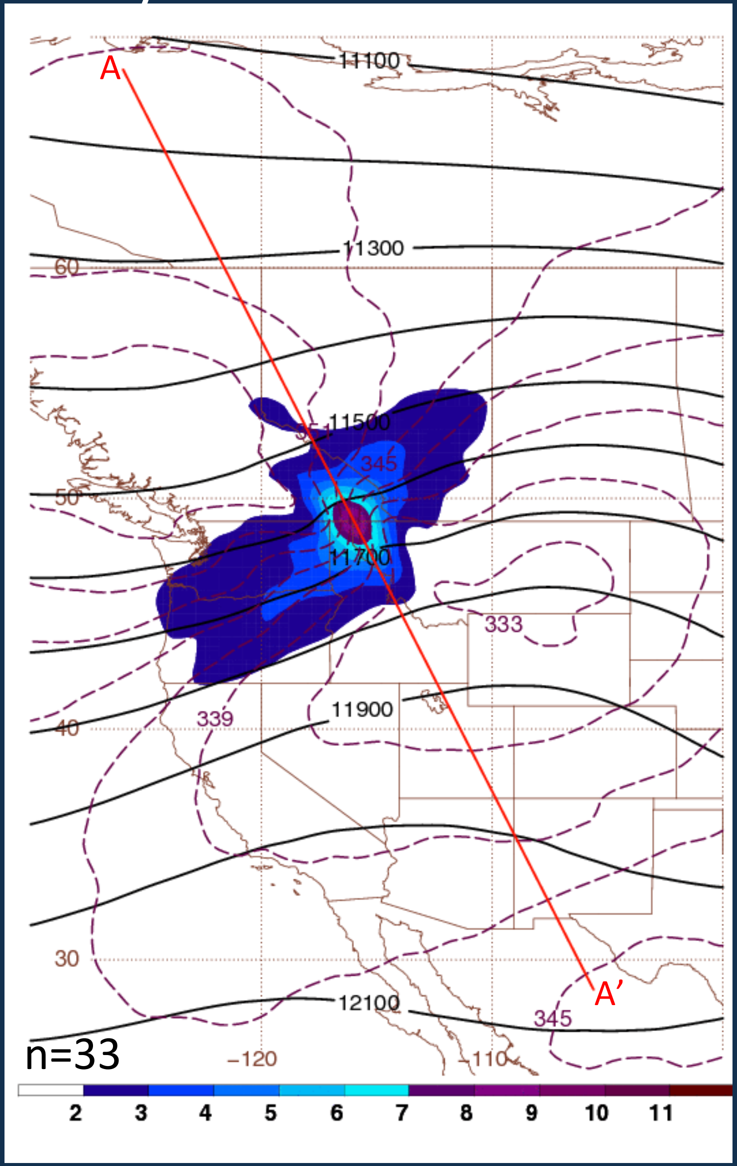
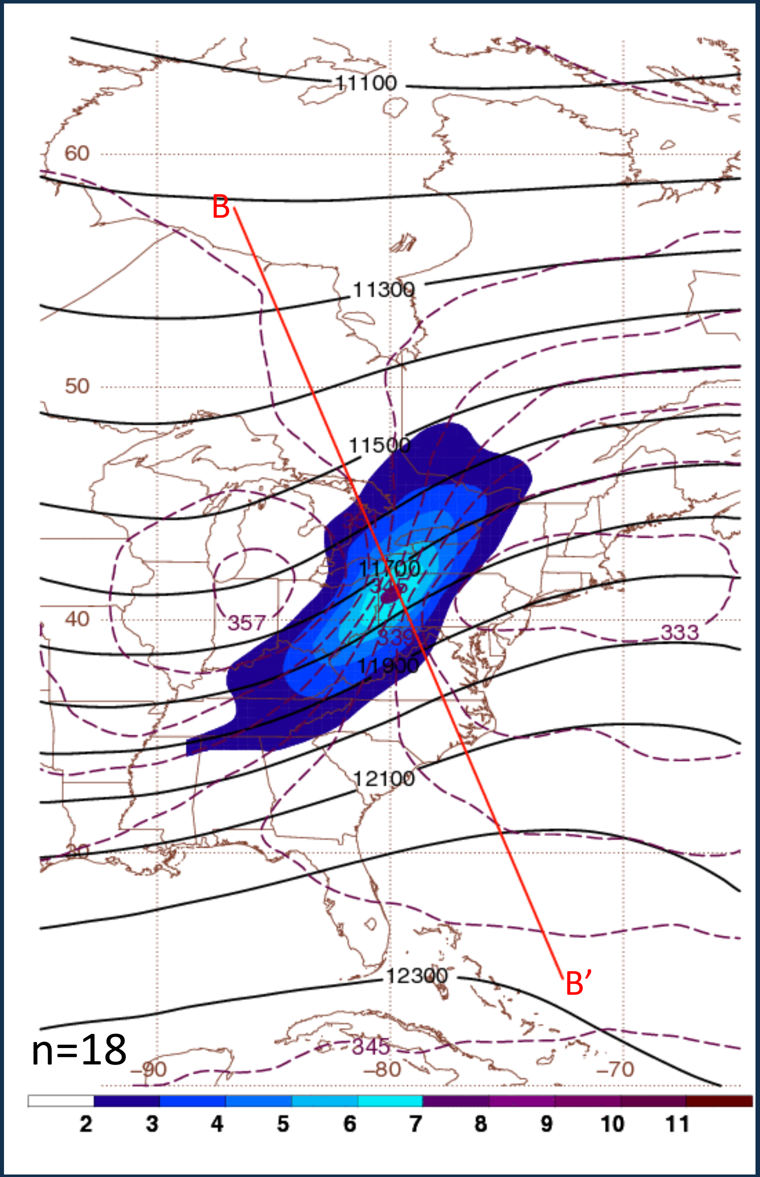


SW Composites
Rocky Mountain
vs.
Eastern US

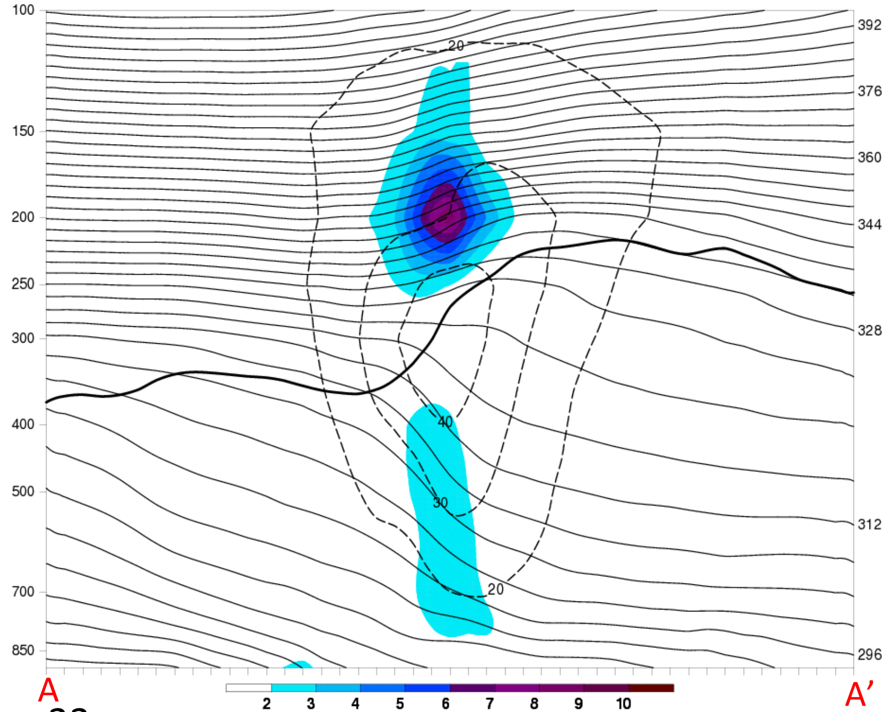
200 hPa Front





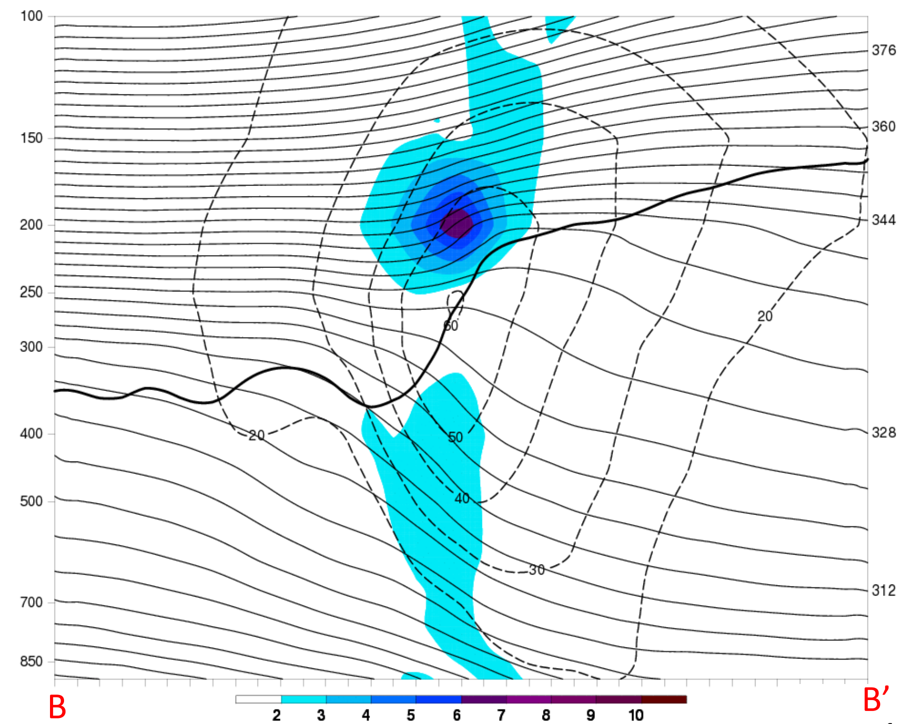
Geopotential height lines in black every 100 m; isentropes in purple dashed every 3 K; Magnitude of the potential temperature gradient shaded in K $(100\text{km})^{-1}$

Rocky Mountains



n=33

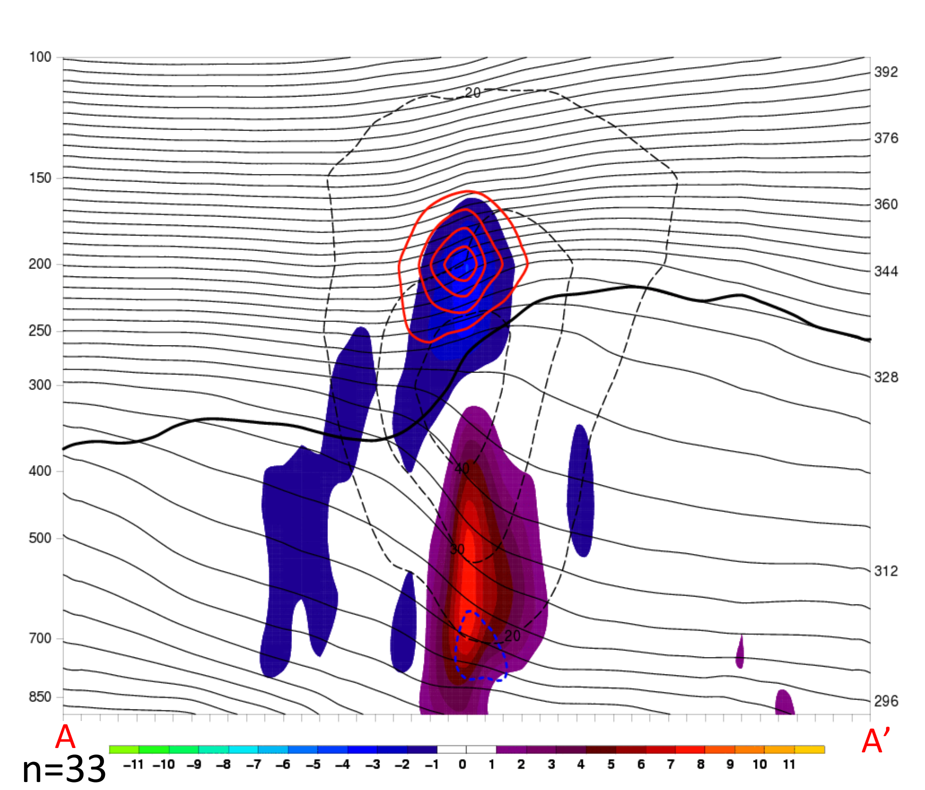
East Coast



n=18

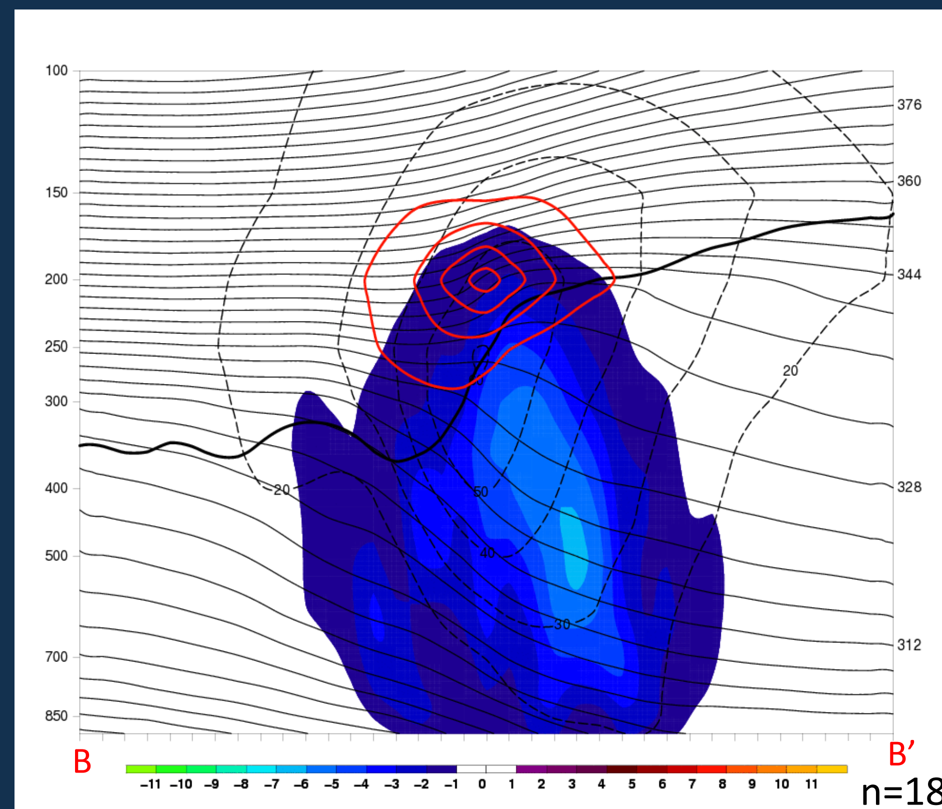
- Potential temperature: thin black lines in K
- Magnitude of the wind: dashed black in m s^{-1}
- Magnitude of the potential temperature gradient: shaded in K $(100\ km)^{-1}$
- 1.5 PVU: thick black solid line

Rocky Mountains



- Potential temperature: thin black lines in K
- Magnitude of the wind: dashed black in m s^{-1}
- Vertical motion: shaded every $1x10^{-3}$ hPa s^{-1}
- Geostrophic Temperature Advection
  - WAA: Red solid
  - CAA: Blue Dashed
- 1.5 PVU: thick black line

East Coast



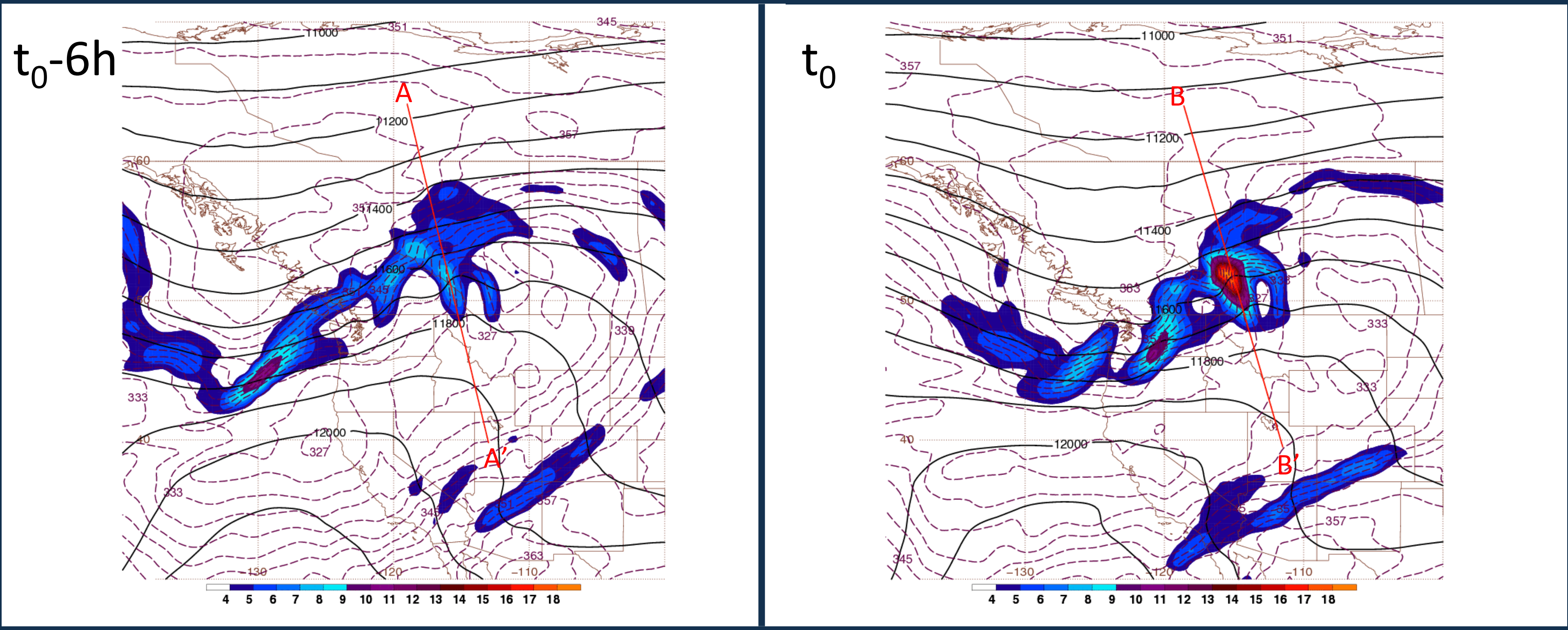
CASE STUDY: SW

Rocky Mountain Case:

0000 UTC 15 January 2008

0000 UTC 15 January 2008
Rocky Mountain Case

200 hPa

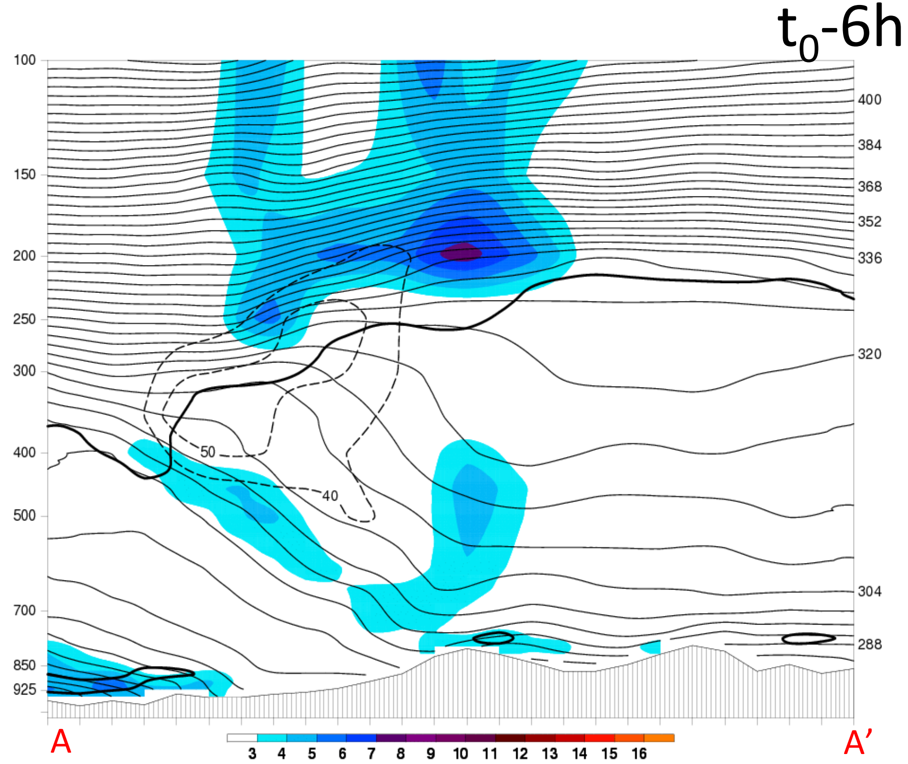


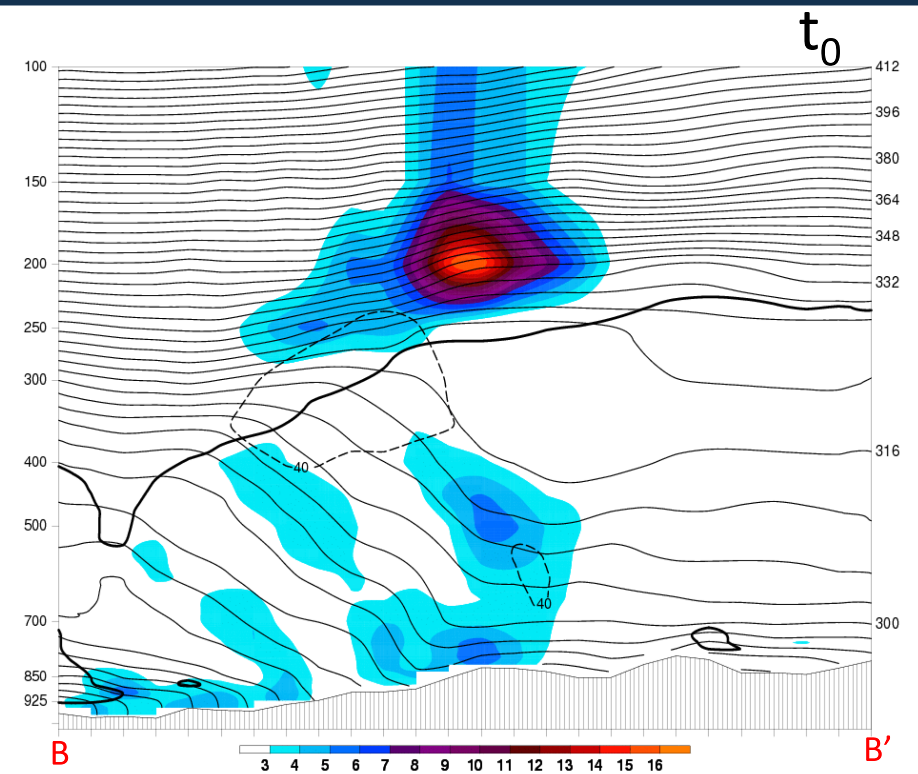
- 200-hPa geopotential height lines in black
- Isentropes in purple dashed every 3 K
- Magnitude of the potential temperature gradient shaded

Cross Sections

0000 UTC 15 January 2008

Rocky Mountain Case





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Cross Sections

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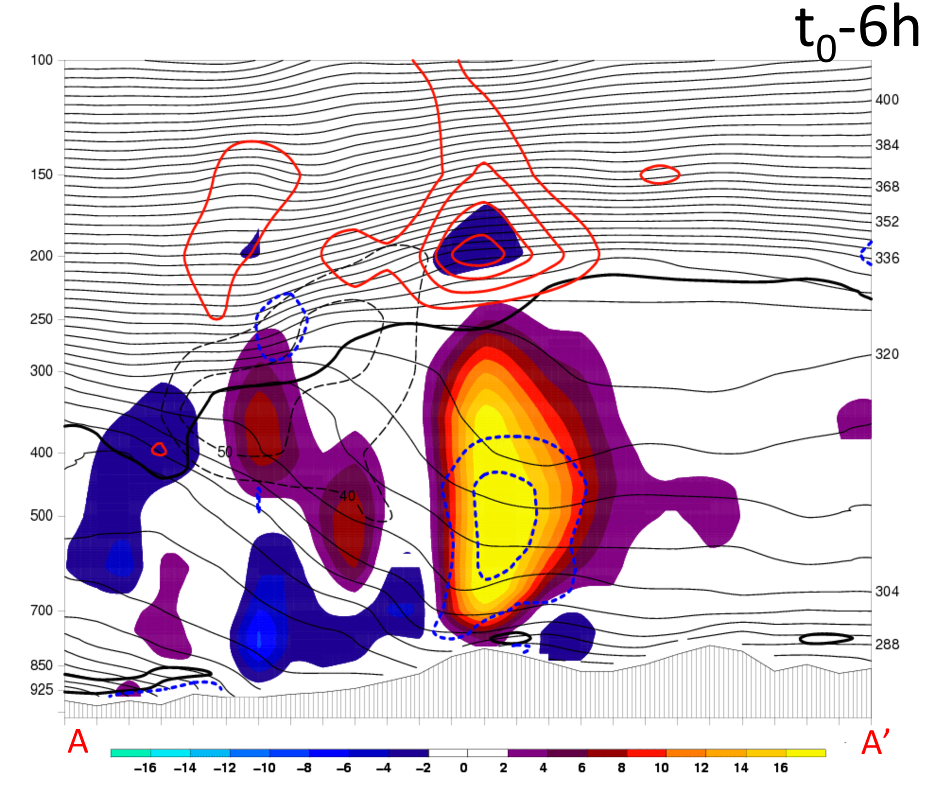
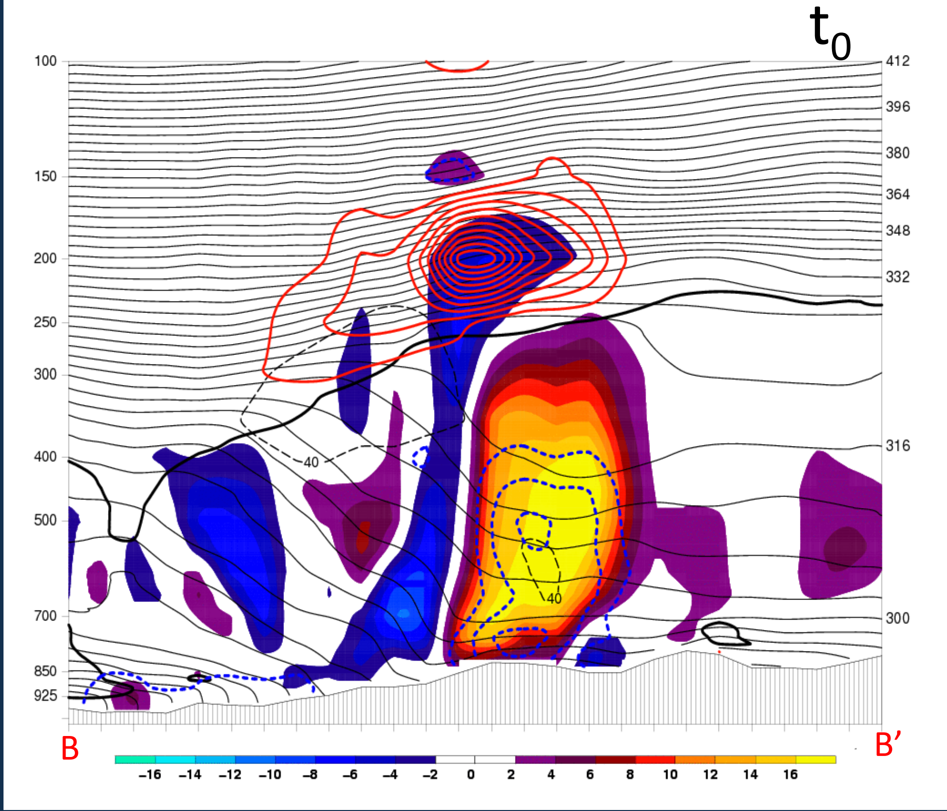
Rocky Mountain Case





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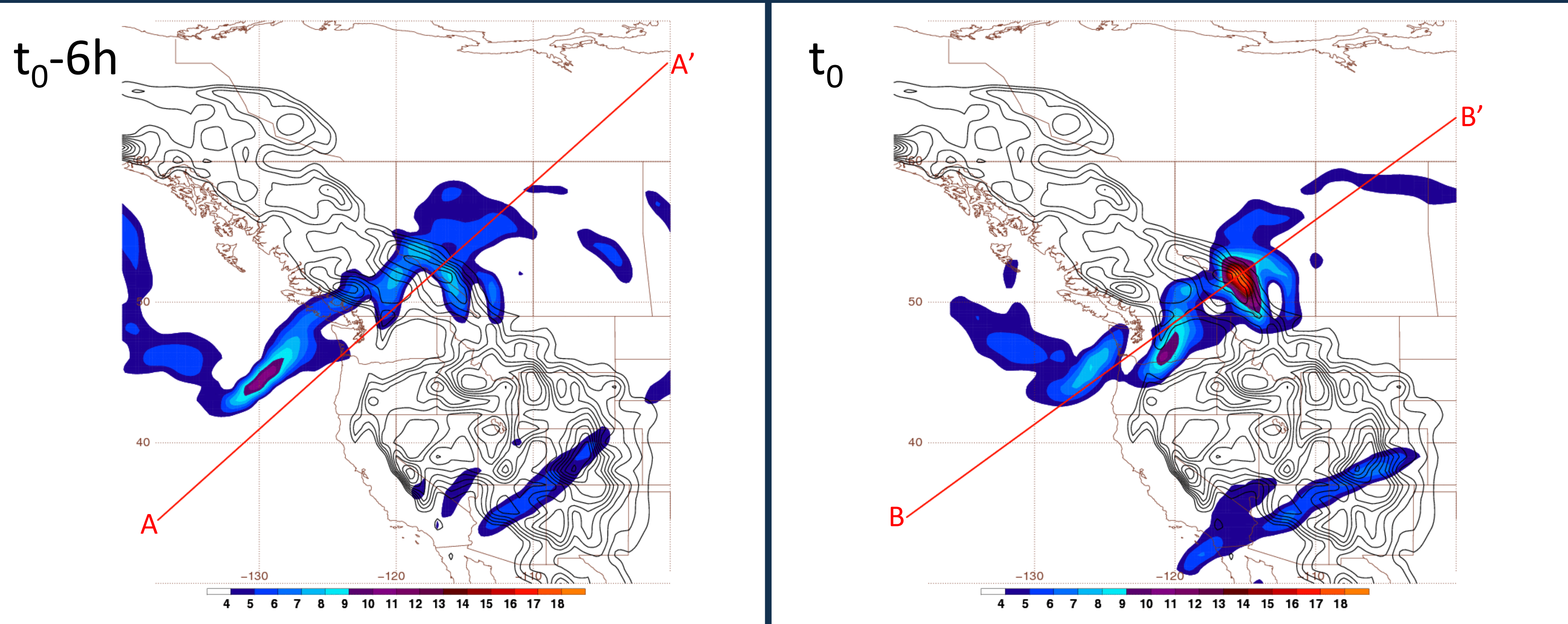
Rocky Mountain Case

200 hPa

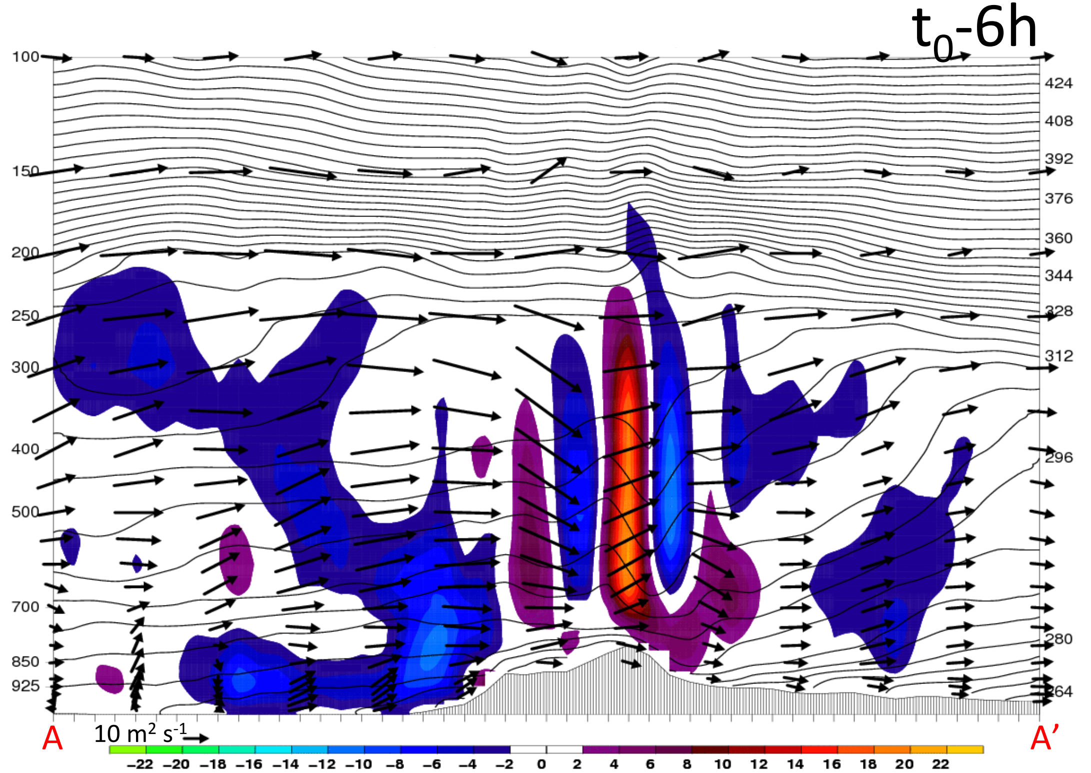


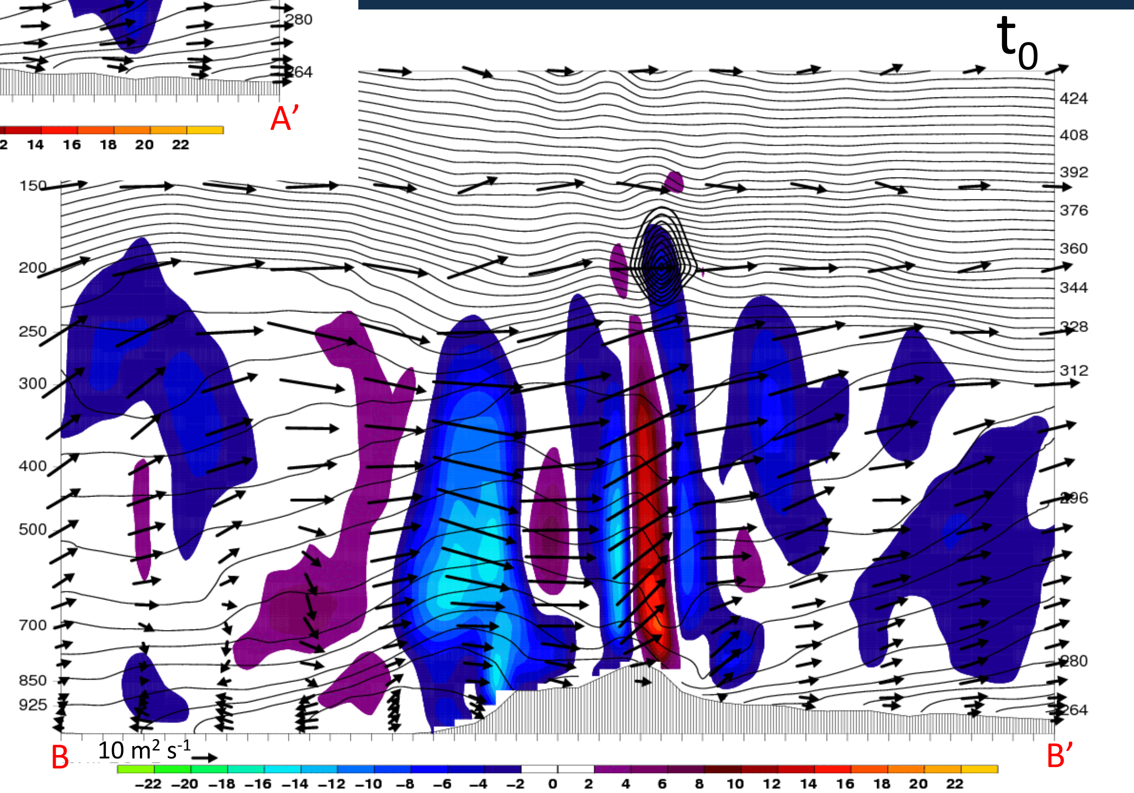
- 200-hPa Potential temperature gradient shaded
- Surface height every 200 m starting at 1000m in black

Cross Sections

0000 UTC 15 January 2008

Rocky Mountain Case





- Potential temperature: thin black lines in K
- Vertical motion every 1×10^{-3} hPa s^{-1} : shaded
- Circulation: arrows
- 1.5 PVU: dark black line
- LSF: thick black lines

CASE STUDY: SW

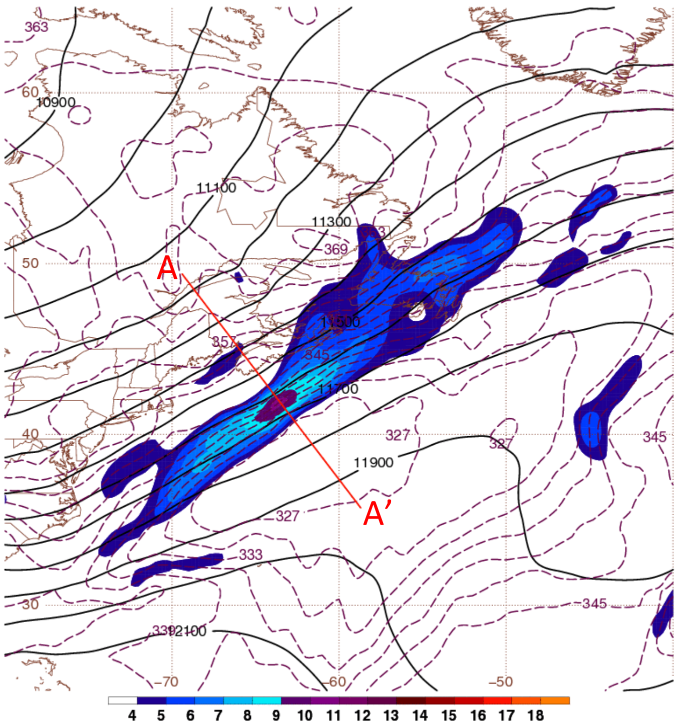
Eastern US Case:

1200 UTC 19 January 2012

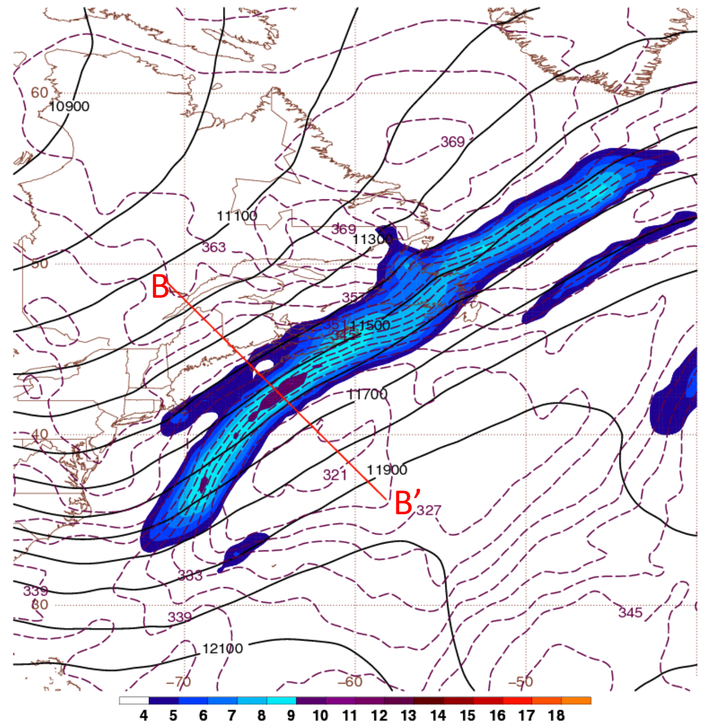
1200 UTC 19 January 2012
East Coast Case

200 hPa

t_0-6h



t_0

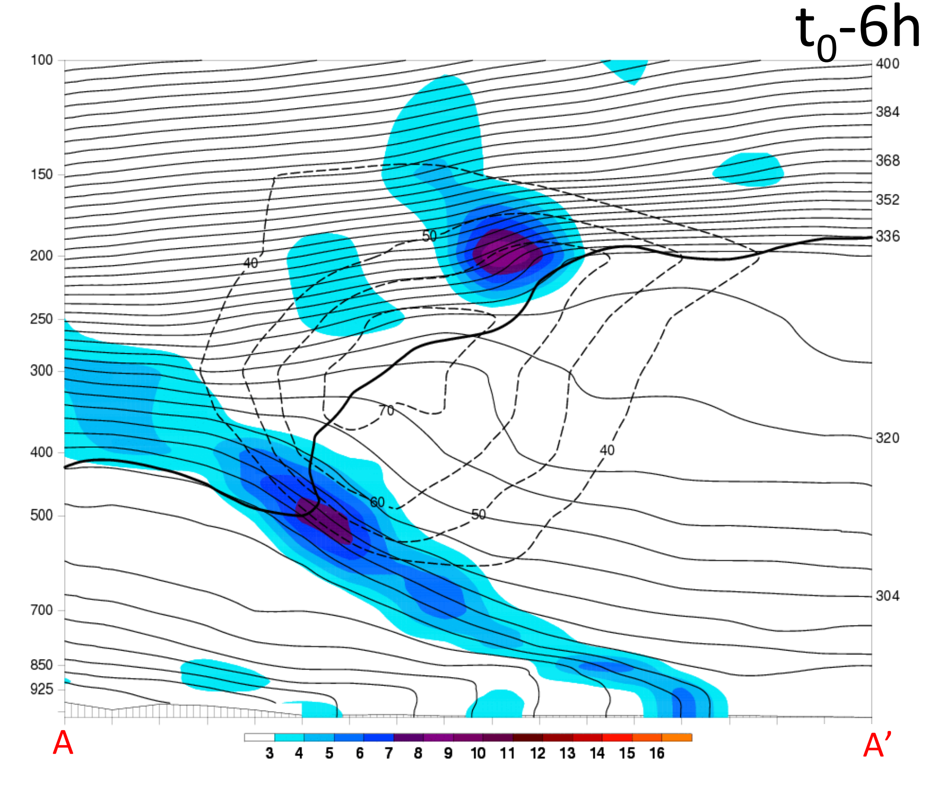


- 200-hPa geopotential height lines in black
- Isentropes in purple dashed every 3 K
- Magnitude of the potential temperature gradient shaded

Cross Sections

1200 UTC 19 January 2012

East Coast Case



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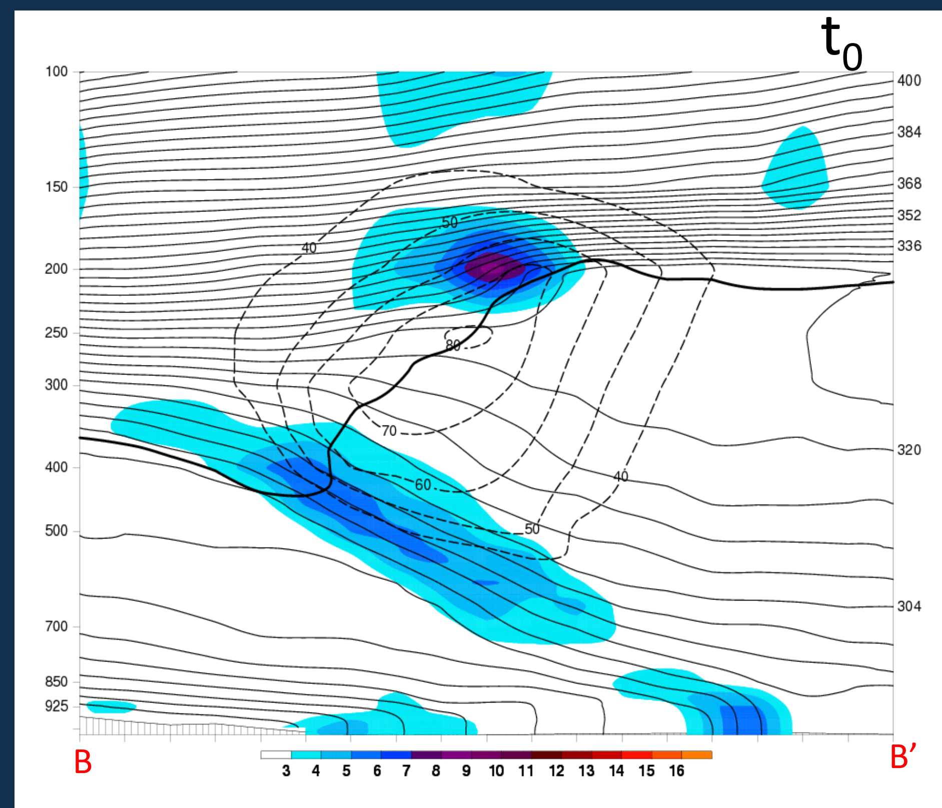

Cross Sections

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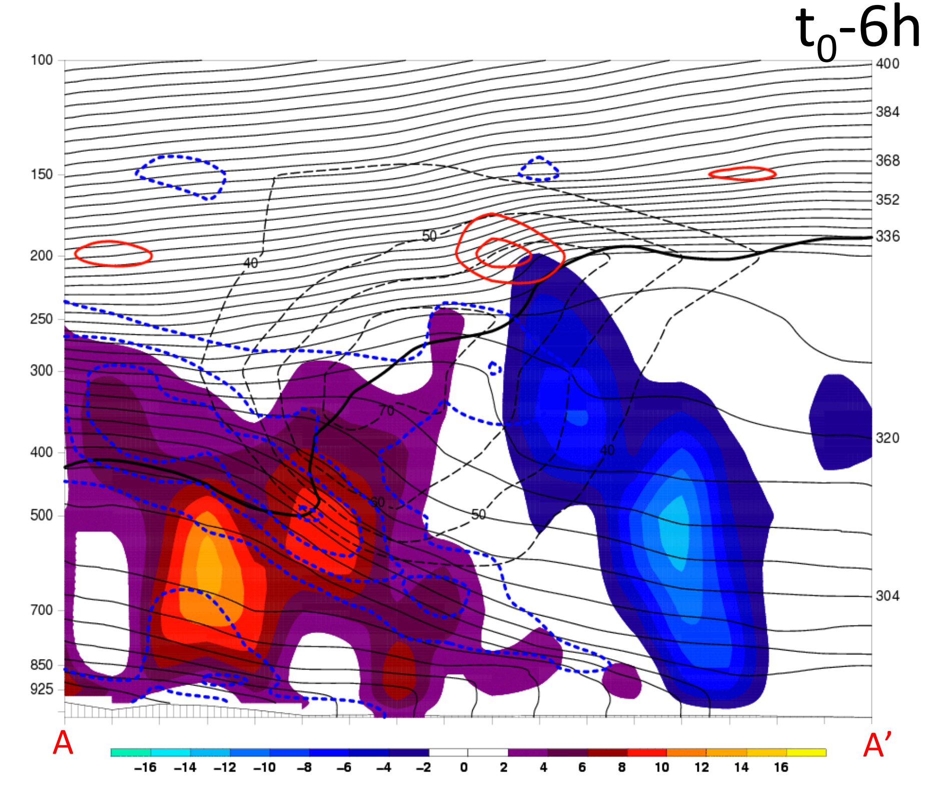
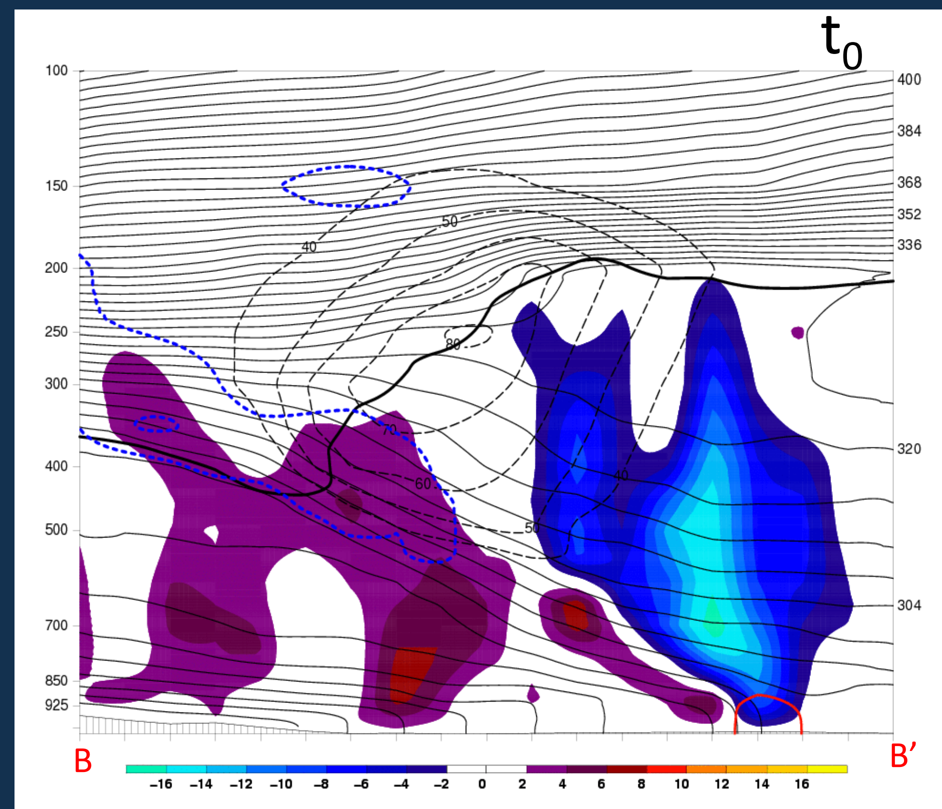
East Coast Case





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- Geostrophic Temperature Advection
  - WAA: Red solid
  - CAA: Blue Dashed
- 1.5 PVU: thick black line

Summary

- LSF development occurs via vertical motion and tilting
- Climatologically there are 2 different pathways to development

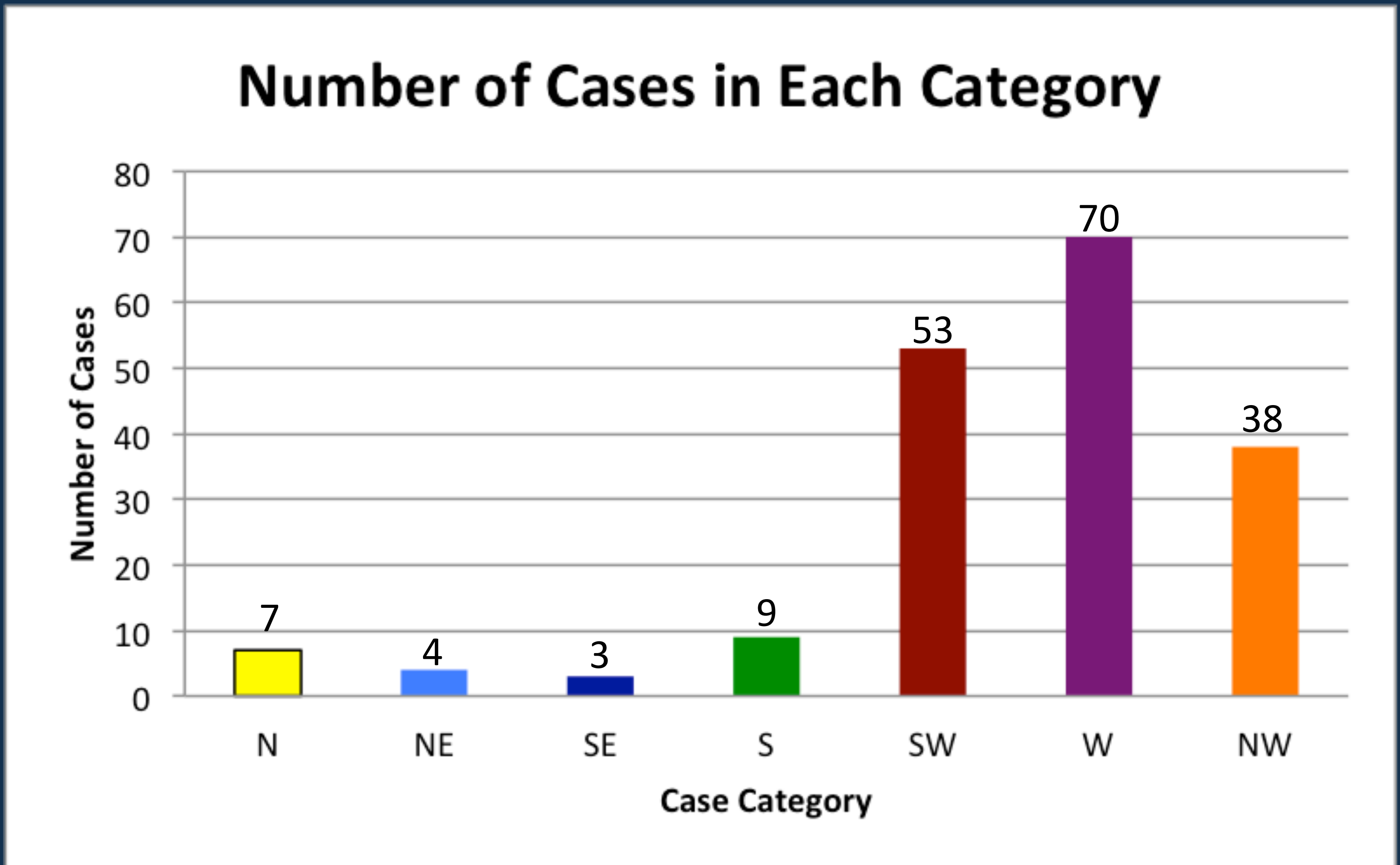
Summary

- **Rocky Mountain Development:**
  - Ascent: topographic gravity waves
  - Maximum in lower stratospheric geostrophic WAA and vertical motion at time of maximum LSF
- **East Coast development:**
  - Ascent: troposphere deep
  - Maximum in lower stratospheric geostrophic WAA and vertical motion prior to maximum LSF

Future Work

- The structure of ULJF systems over topography and the ocean
- Impact of LSFs on synoptic weather
- Impact of long-lived LSFs on the lower stratospheric structure

Extra Slides

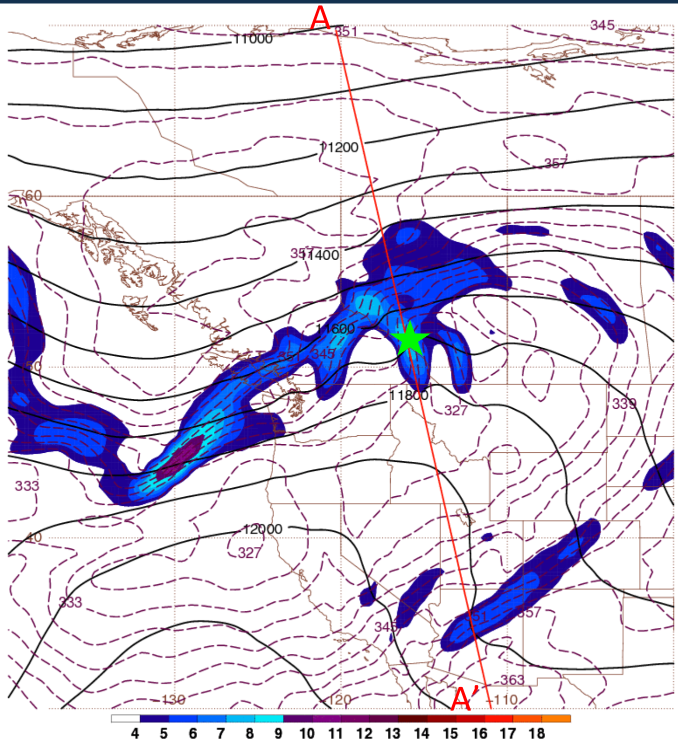


Number of Cases in Each Category
80
70
60
50
40
30
20
10
0
Number of Cases
7
4
3
9
53
70
38
N
NE
SE
S
SW
W
NW
Case Category

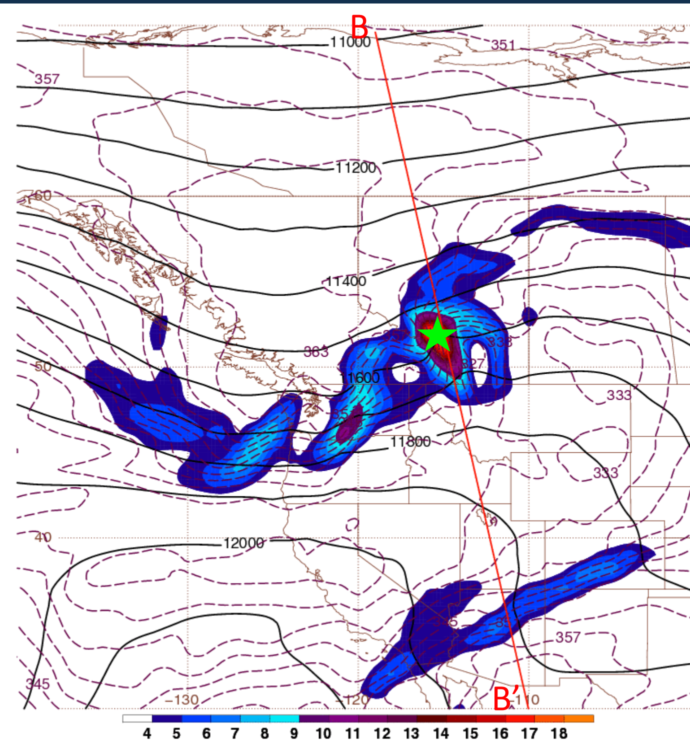
0000 UTC 15 January 2008
Rocky Mountain Case

200 hPa

t-6h



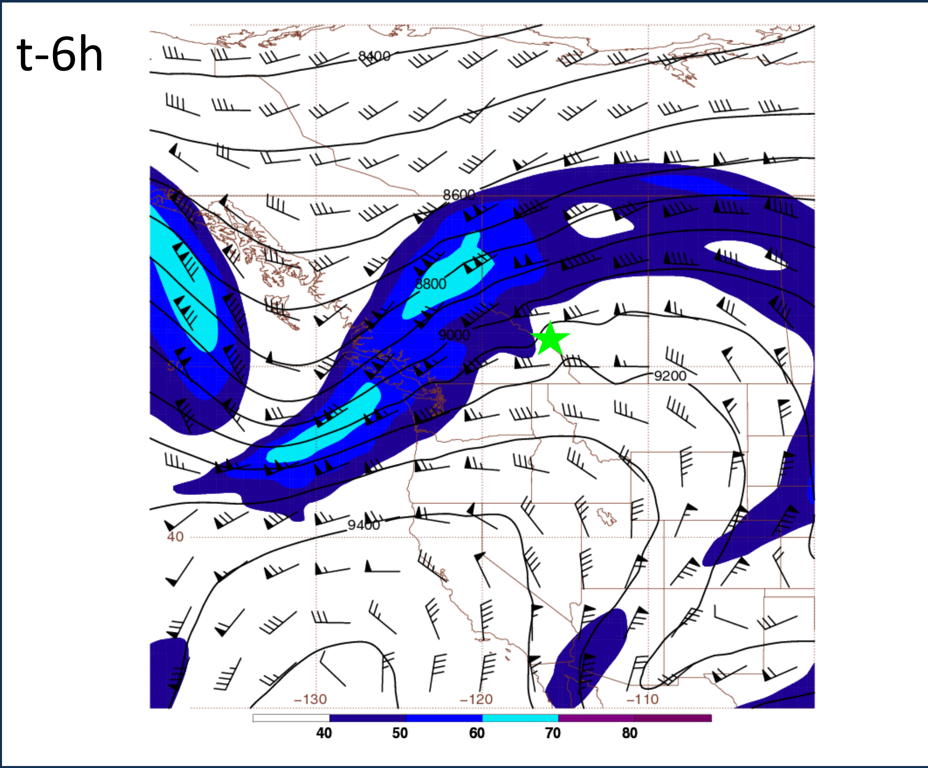
t-0

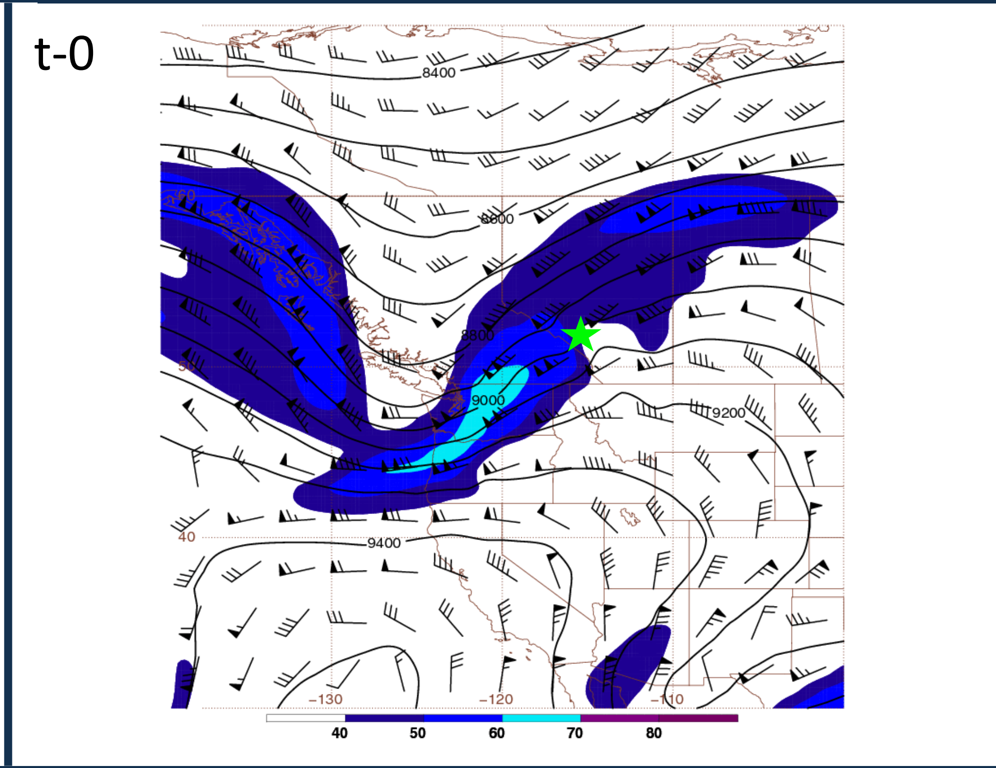


- 200-hPa geopotential height lines in black
- Isentropes in purple dashed every 3 K
- Magnitude of the potential temperature gradient shaded

0000 UTC 15 January 2008
Rocky Mountain Case

300 hPa

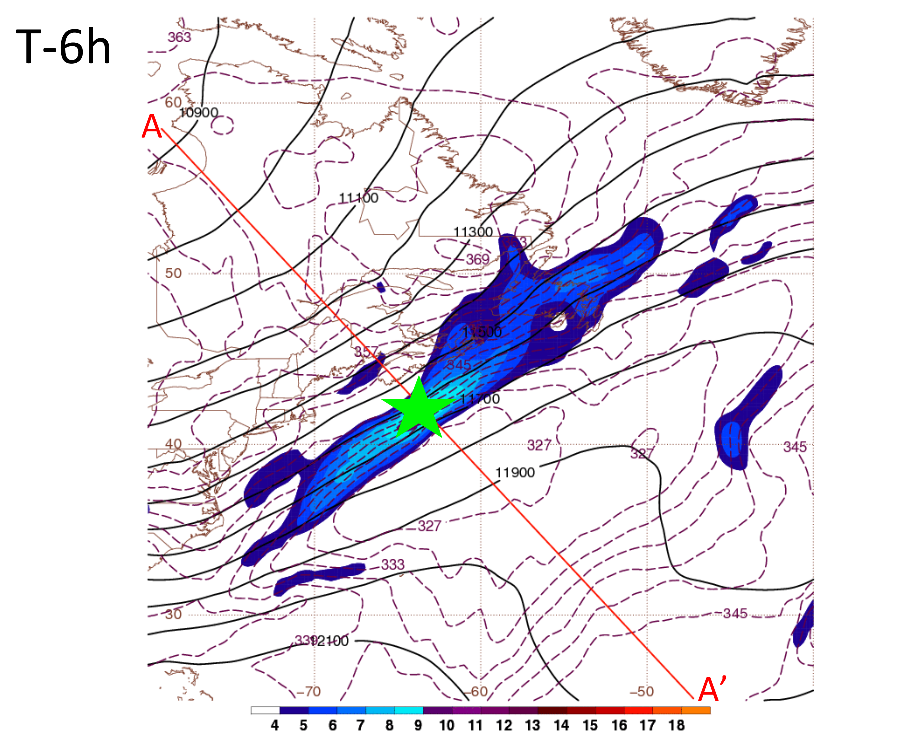


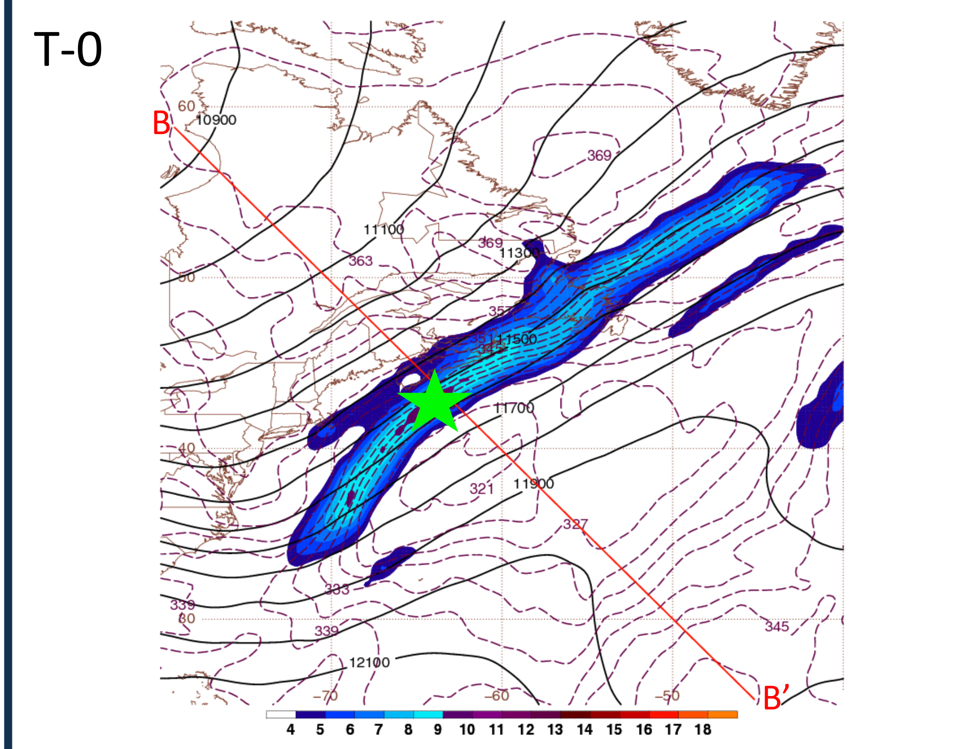


- 300-hPa geopotential height lines in black
- Magnitude of the wind speed shaded
- Wind barbs in knots.

1200 UTC 19 January 2012
East Coast Case

200 hPa





- 200-hPa geopotential height lines in black
- Isentropes in purple dashed every 3 K
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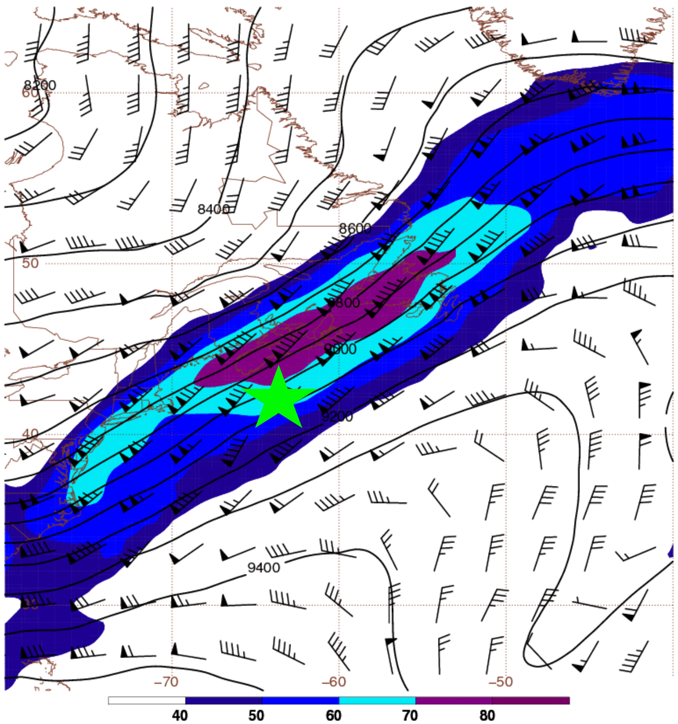
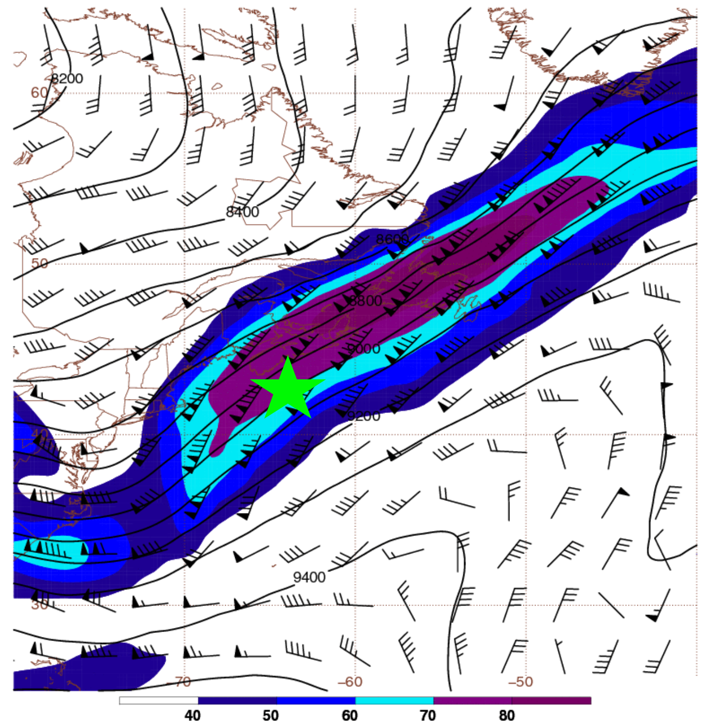
300 hPa

T-6h



T-0



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