A Climatology of Lower Stratospheric Fronts over North America

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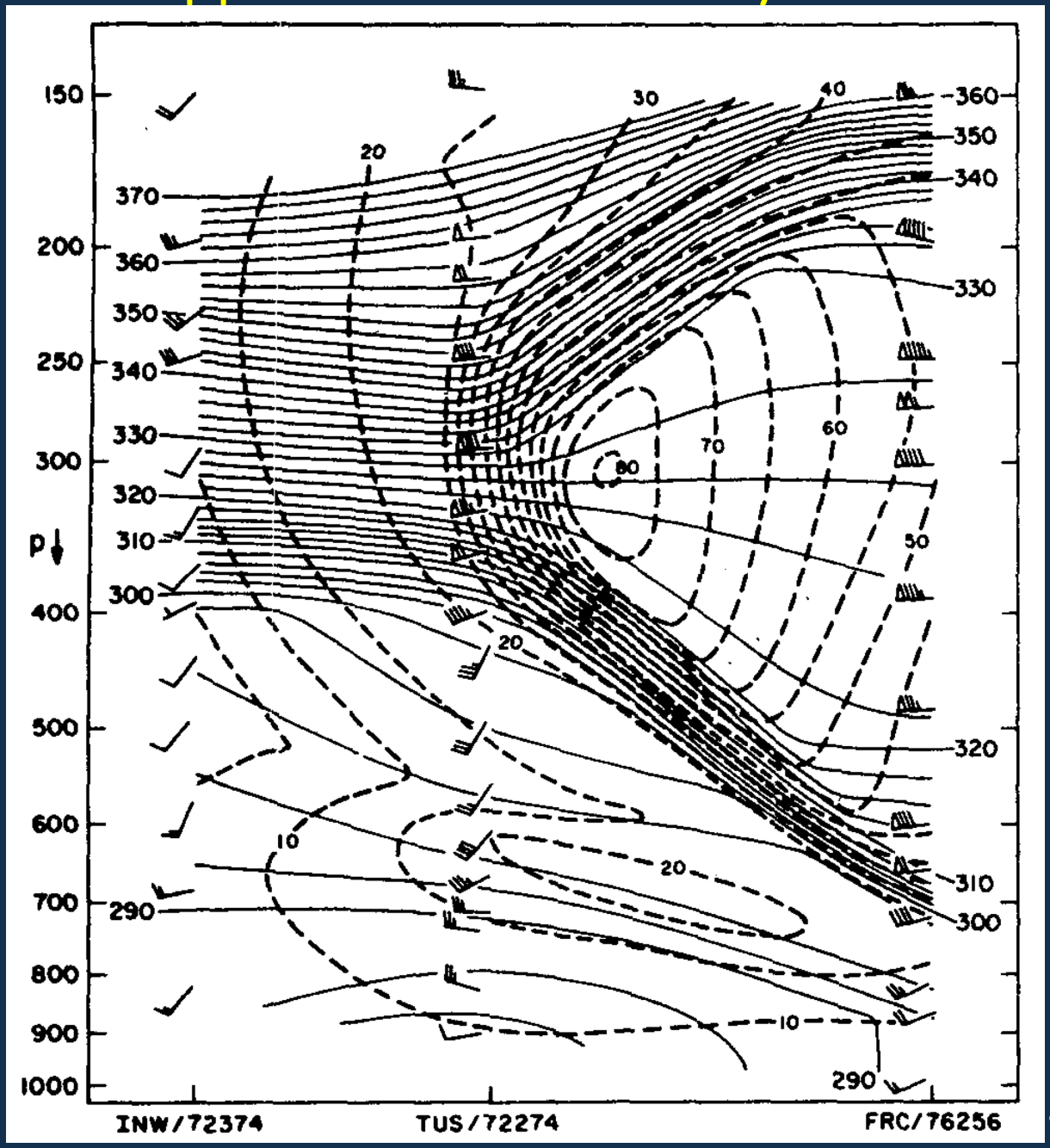
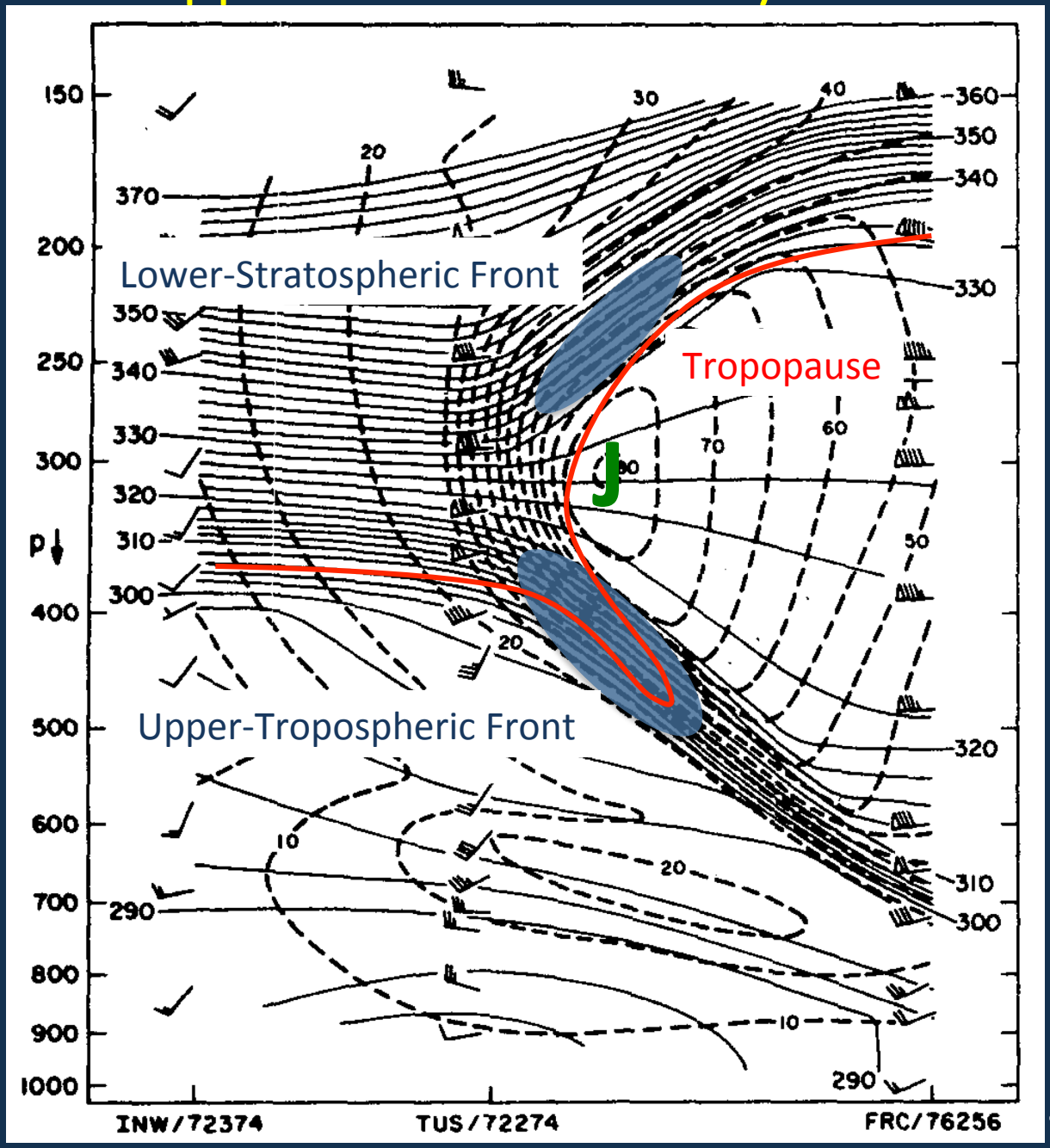
Sainte-Adele, Quebec, CA

Upper-Level Jet-Front System



Shapiro 1981

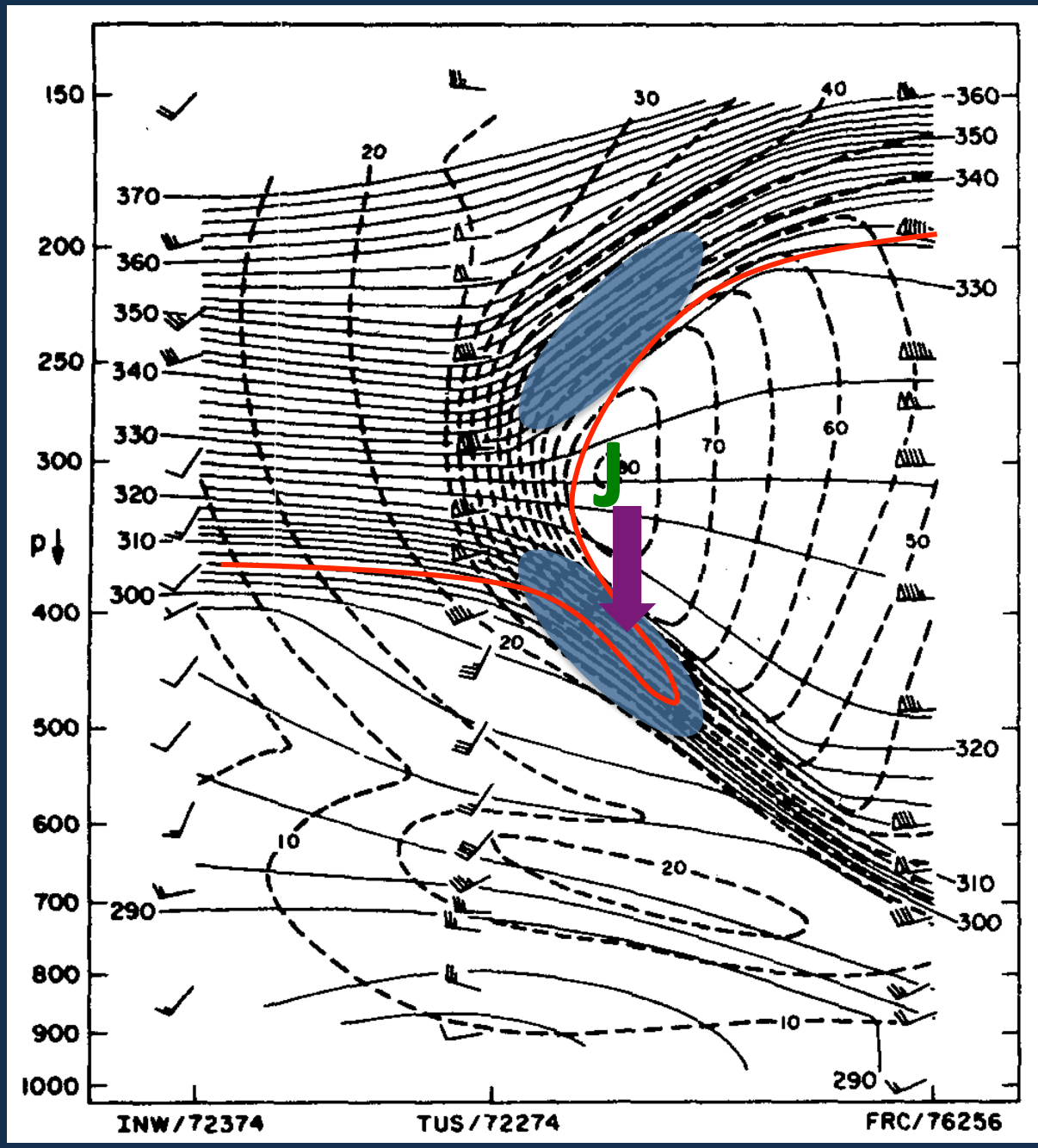
Upper-Level Jet-Front System



Shapiro 1981

Background and Motivation

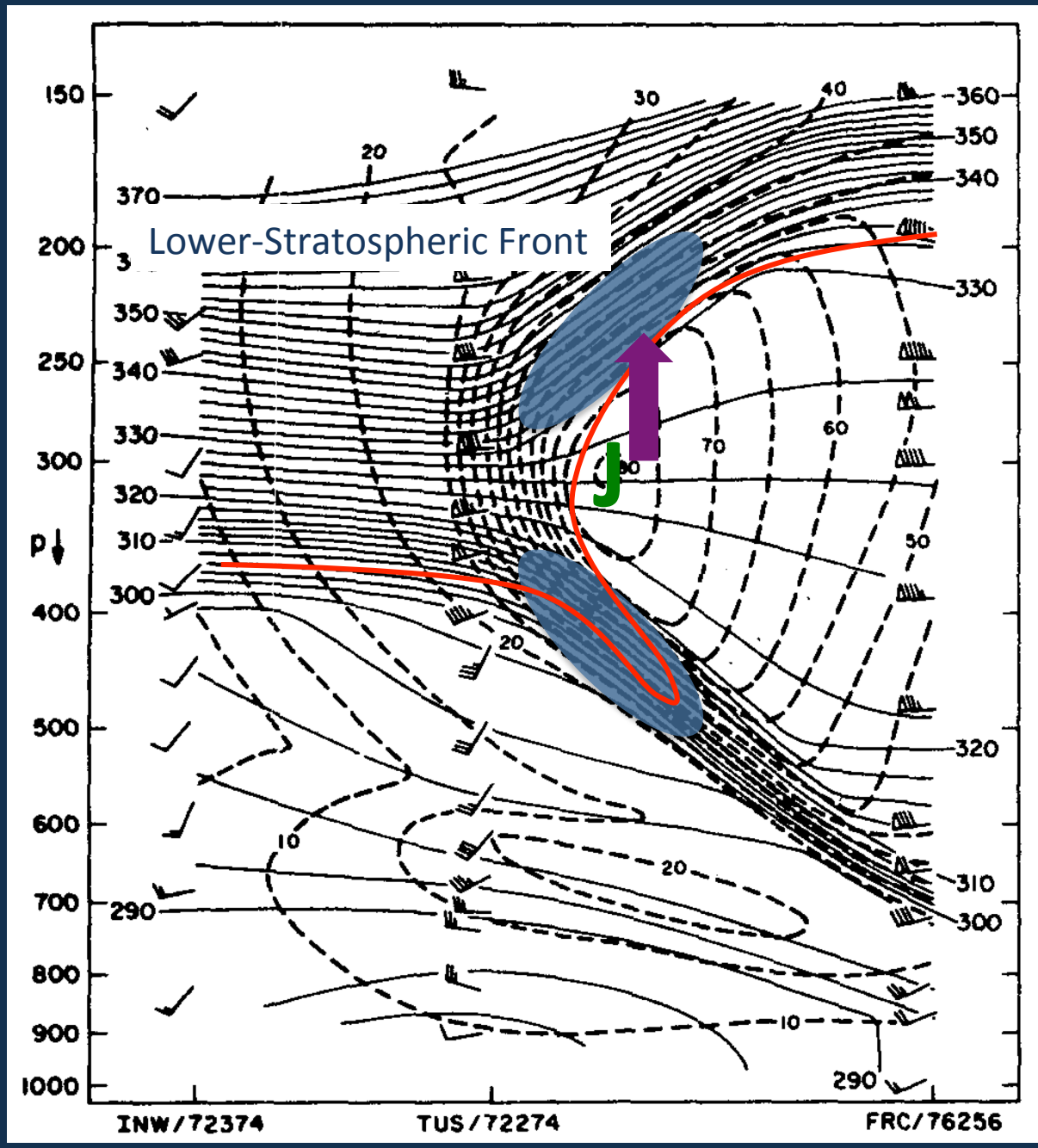
- Upper-Tropospheric Fronts (Shapiro 1981; Keyser and Shapiro 1985):
  - develop via tilting (descent)
  - High PV air from the stratosphere can enter the troposphere
- This positive PV anomaly can act as an upper-level precursor to surface cyclongensis events (Lackmann et al. 1997)



Shapiro 1981

Background and Motivation

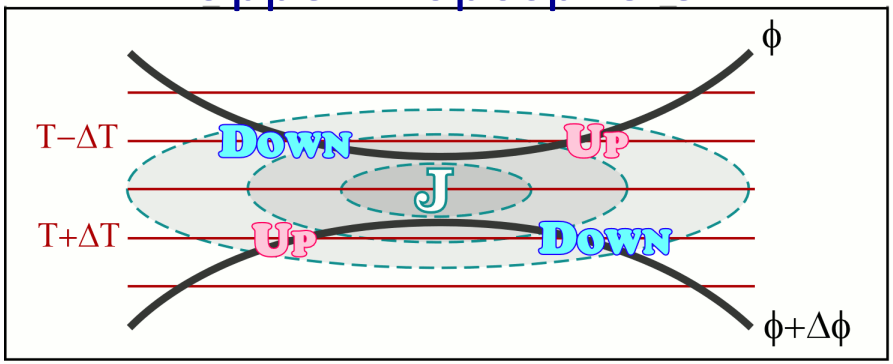
- Lower-Stratospheric Fronts develop via tilting:
  - ascent
- Little research has been done on lower stratospheric fronts
- Without a clear picture of the life cycle of LSFs we do not have an accurate understanding of the entire Upper Level Jet-Front (ULJF) System



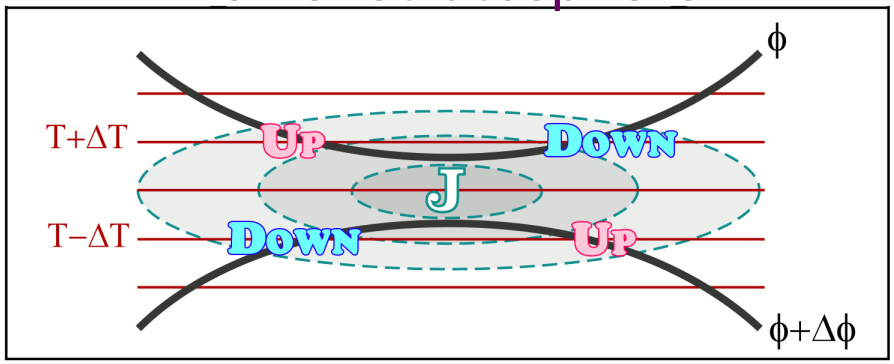
Shapiro 1981

Jet Circulations

Below the jet core: Upper Troposphere



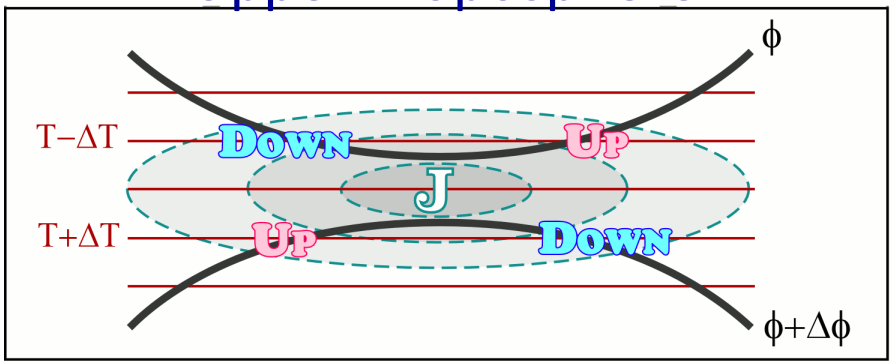
Above the jet core: Lower Stratosphere



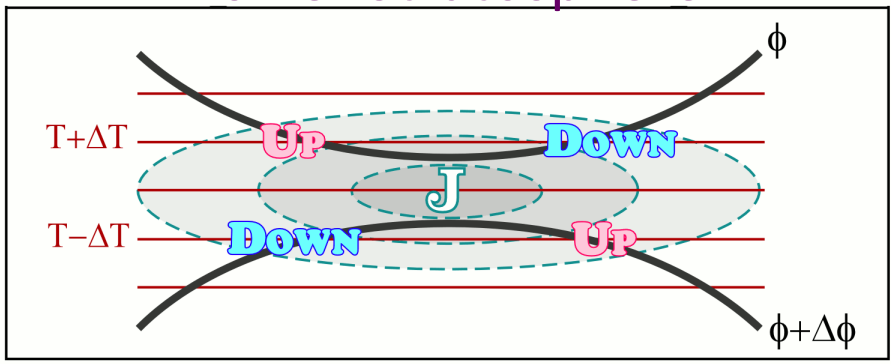
Lang and Martin (2012)

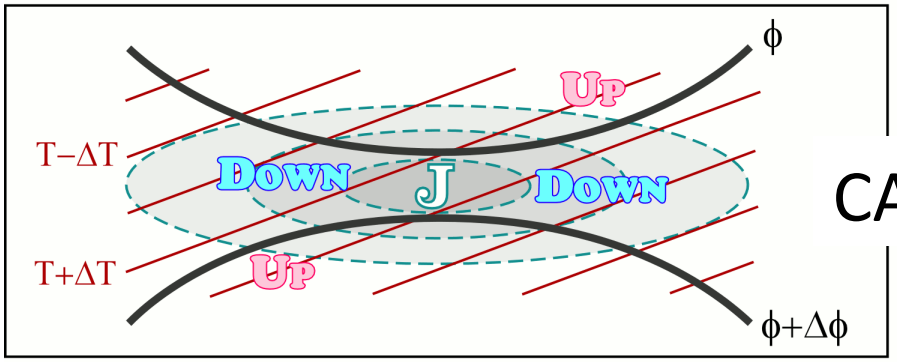
Jet Circulations

Below the jet core: Upper Troposphere

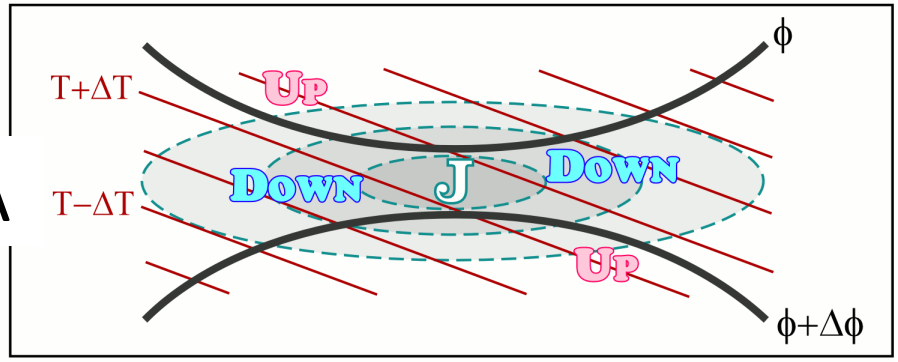


Above the jet core: Lower Stratosphere





CAA

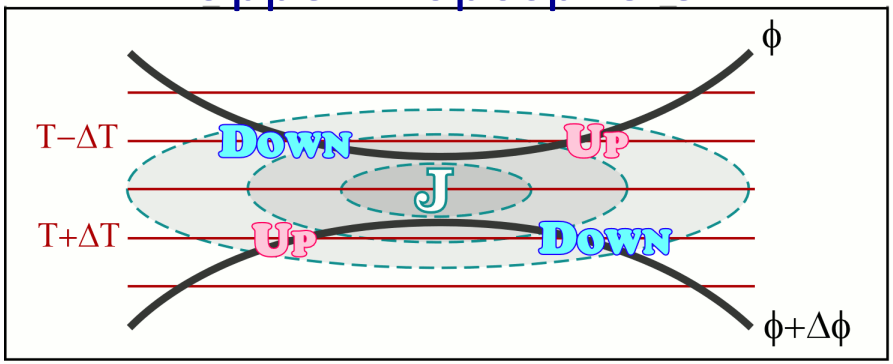


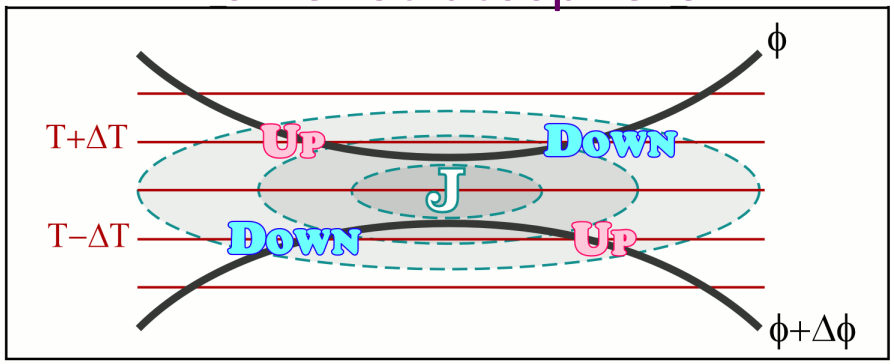
Lang and Martin (2012)

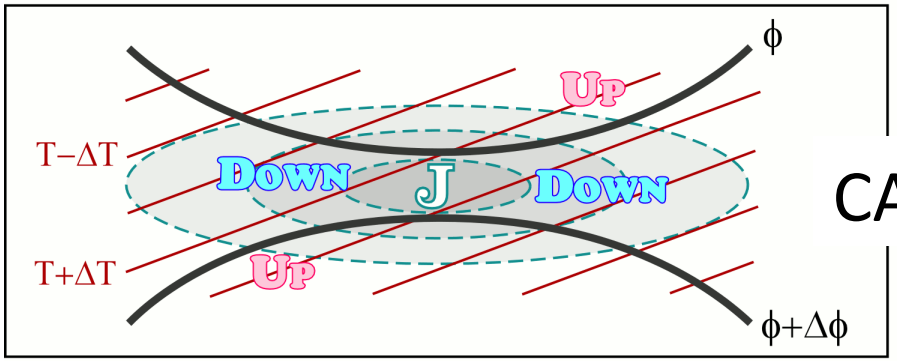
Jet Circulations

Below the jet core: Upper Troposphere

Above the jet core: Lower Stratosphere







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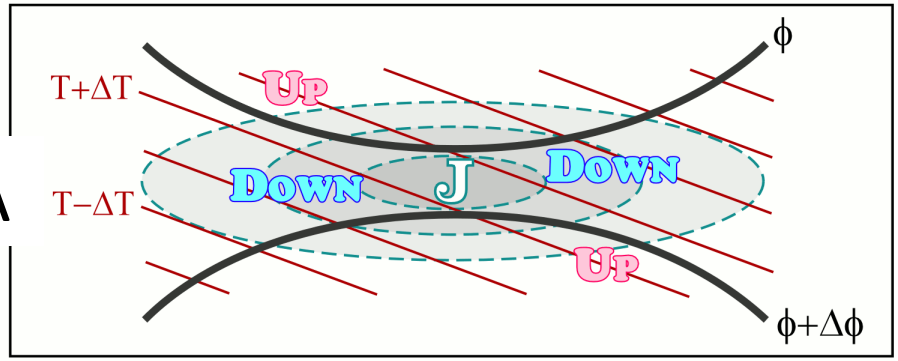
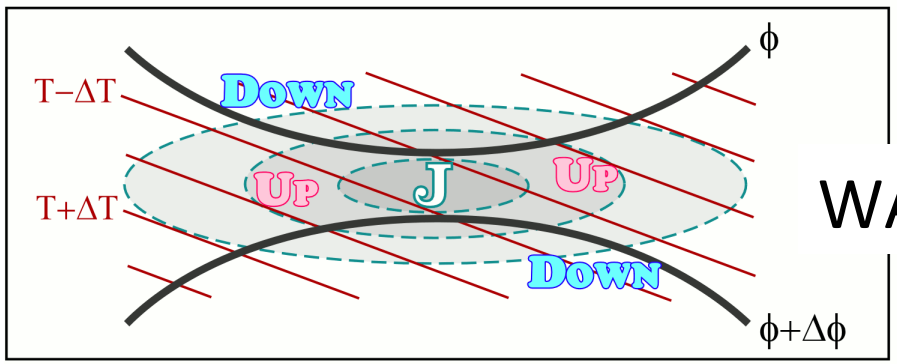
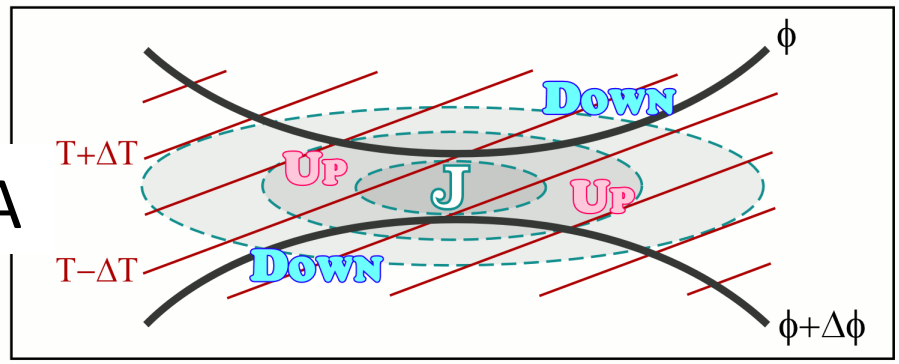




WAA



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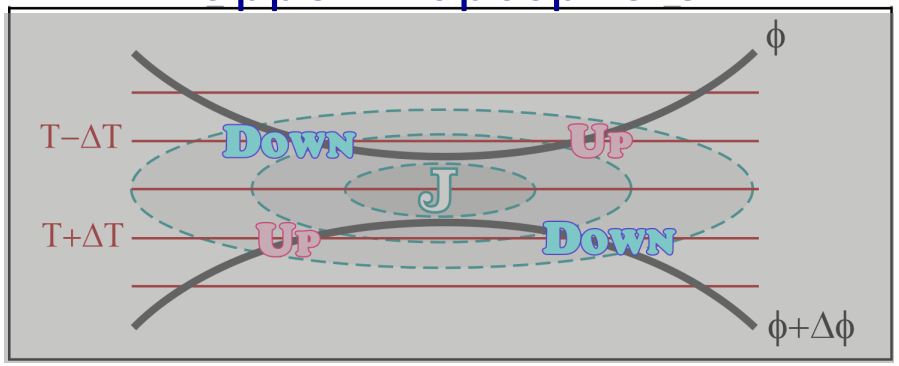

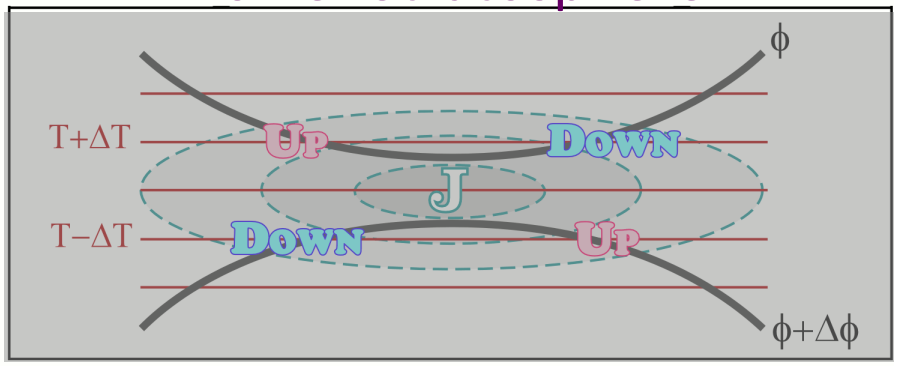

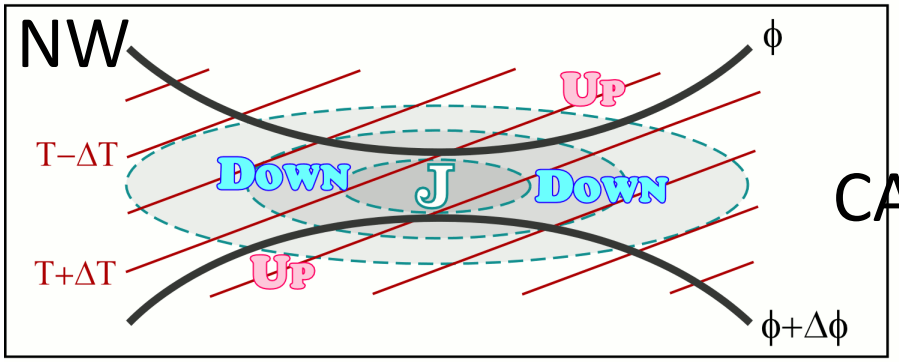

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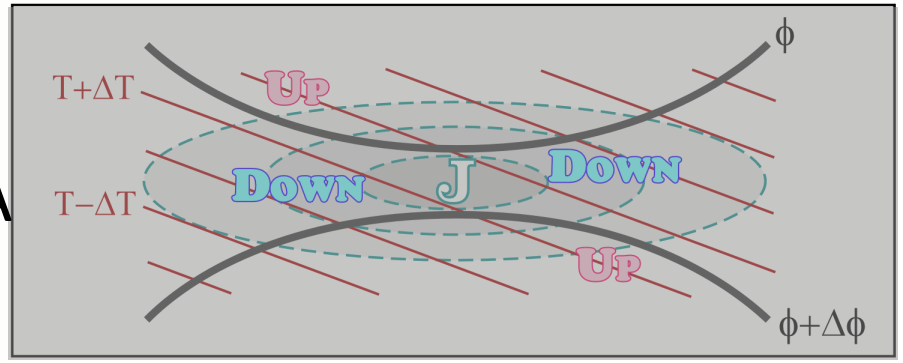

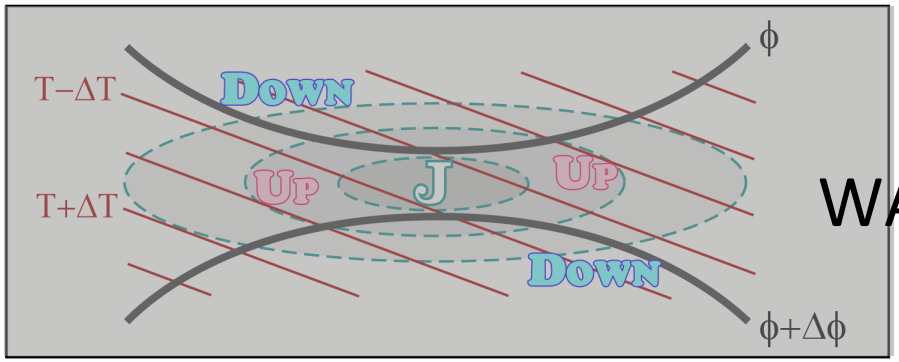

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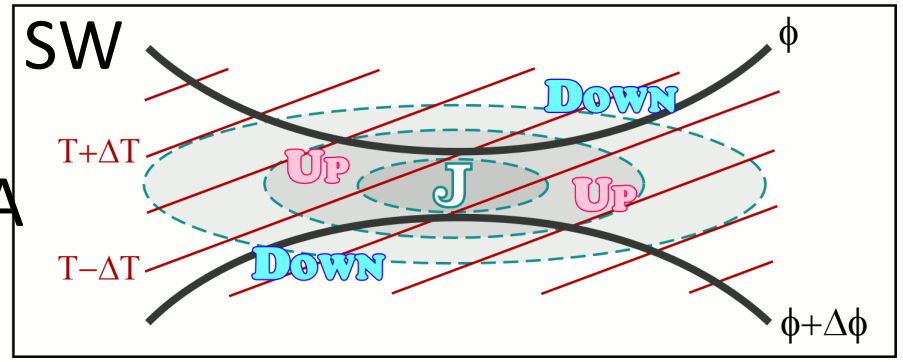
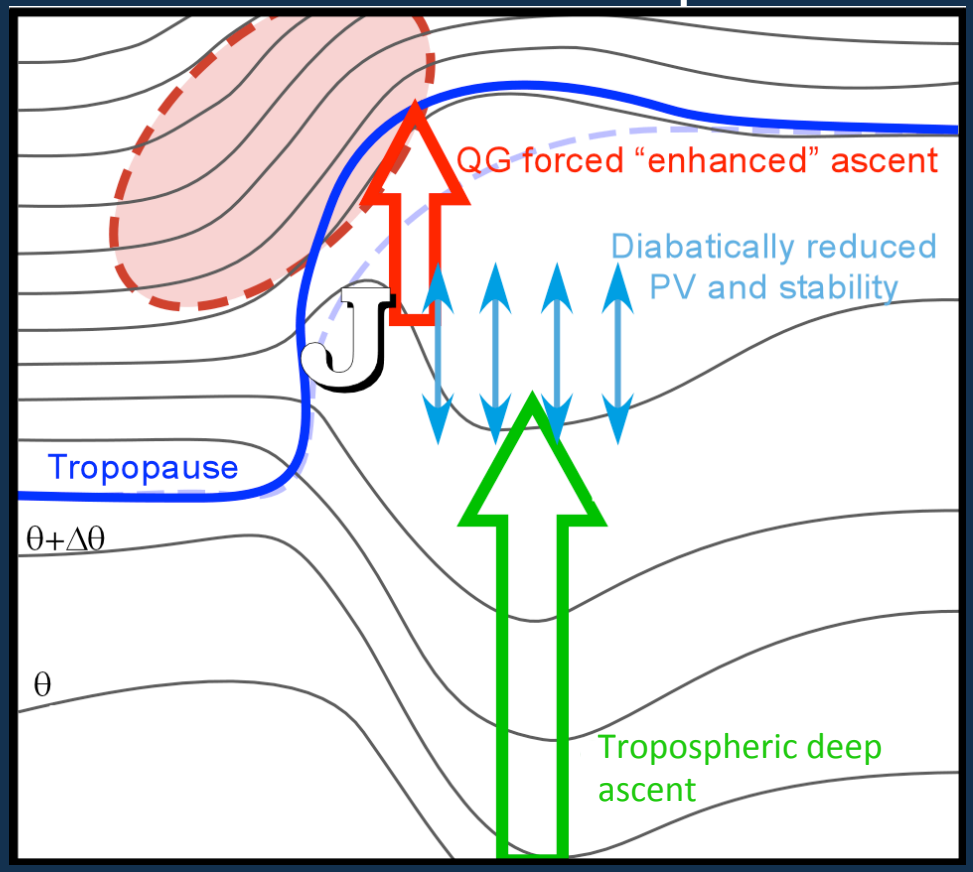


Lang and Martin (2012)

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

Previous Research

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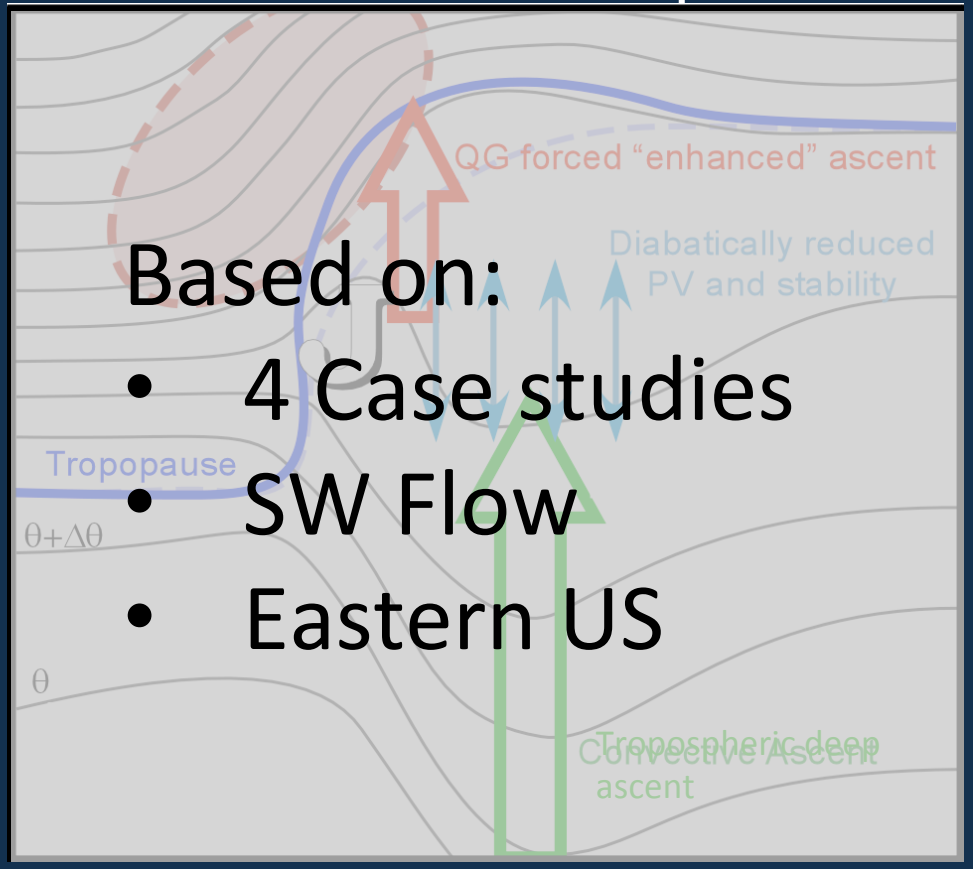

Based on:

- 4 Case studies
- SW Flow
- Eastern US

Isentropes: thin black lines; **Dynamic tropopause**: blue line;
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Previous Research

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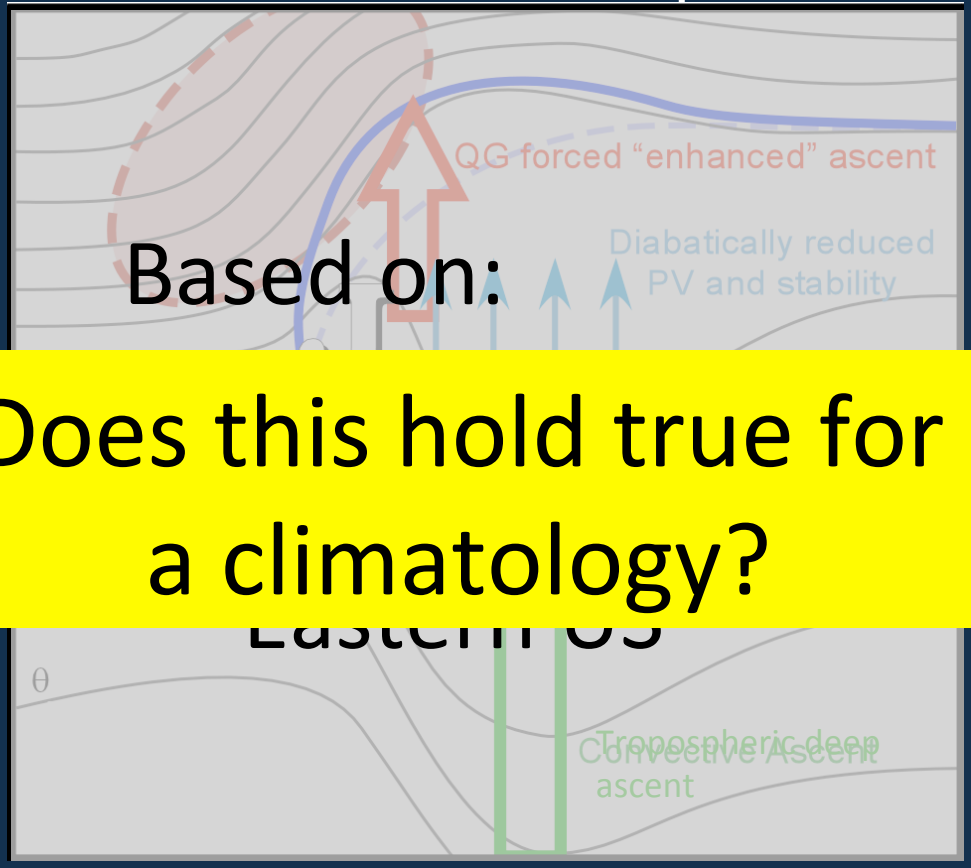
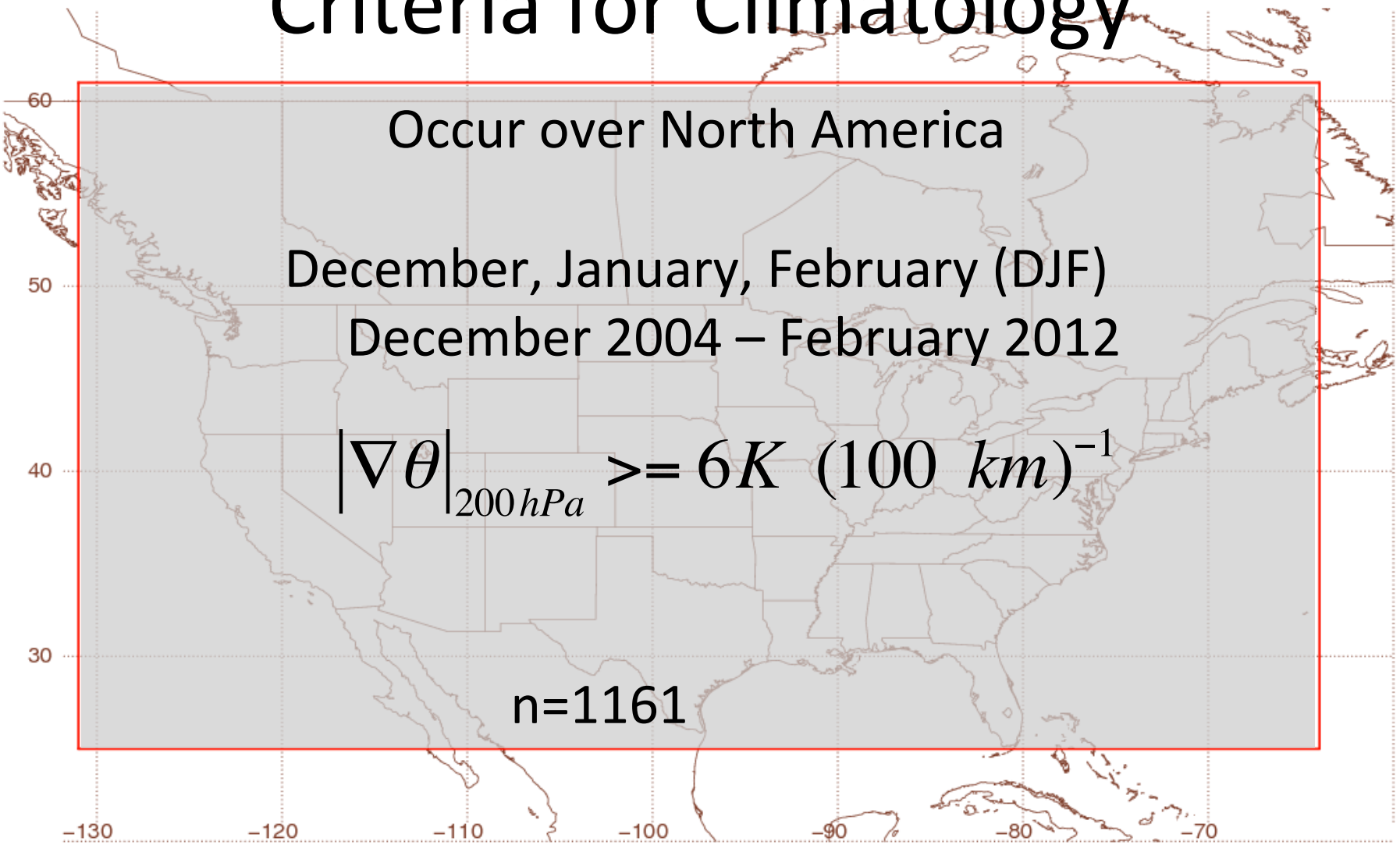


Based on:

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



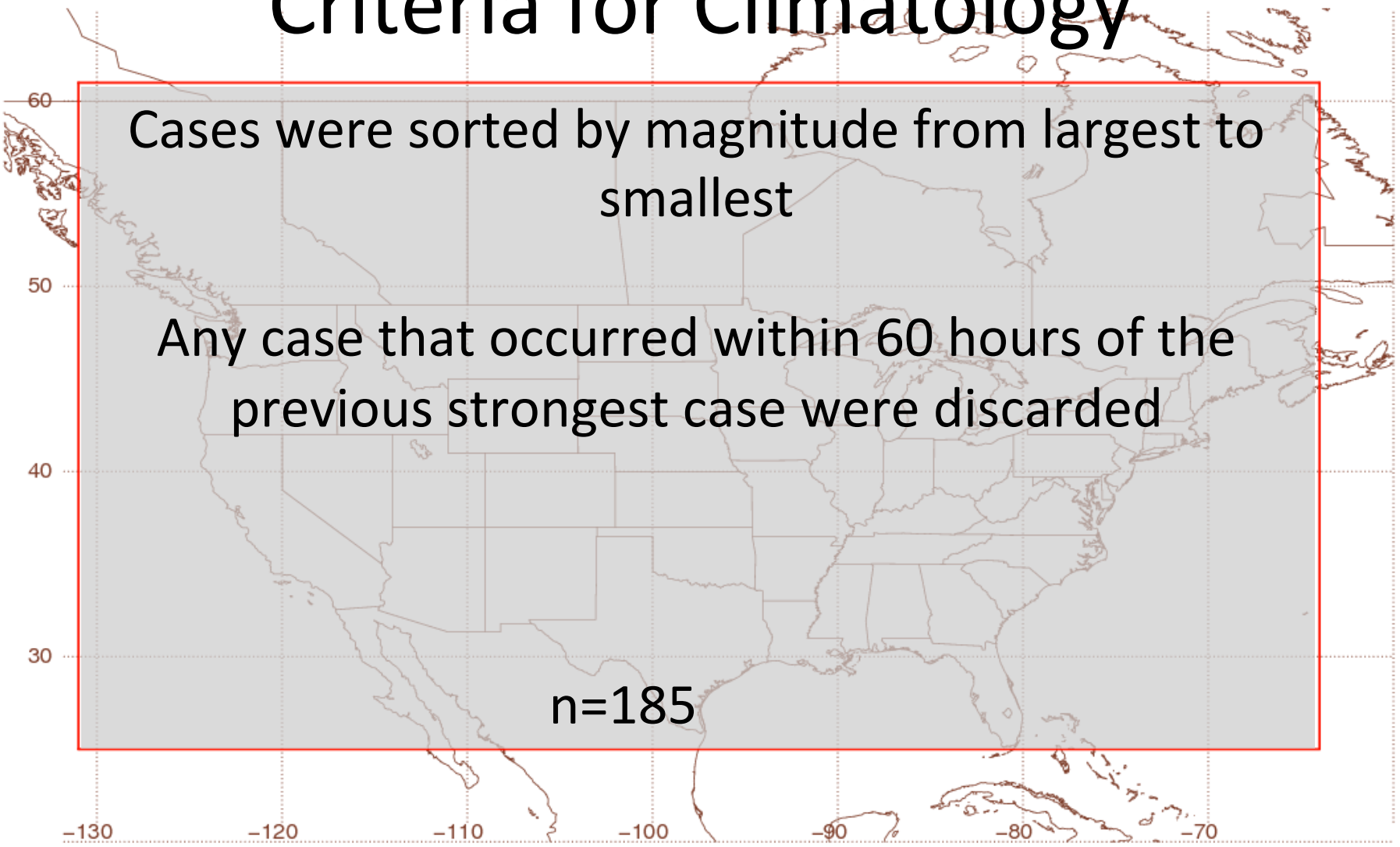
Occur over North America

December, January, February (DJF)
December 2004 – February 2012

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

n=1161

Criteria for Climatology

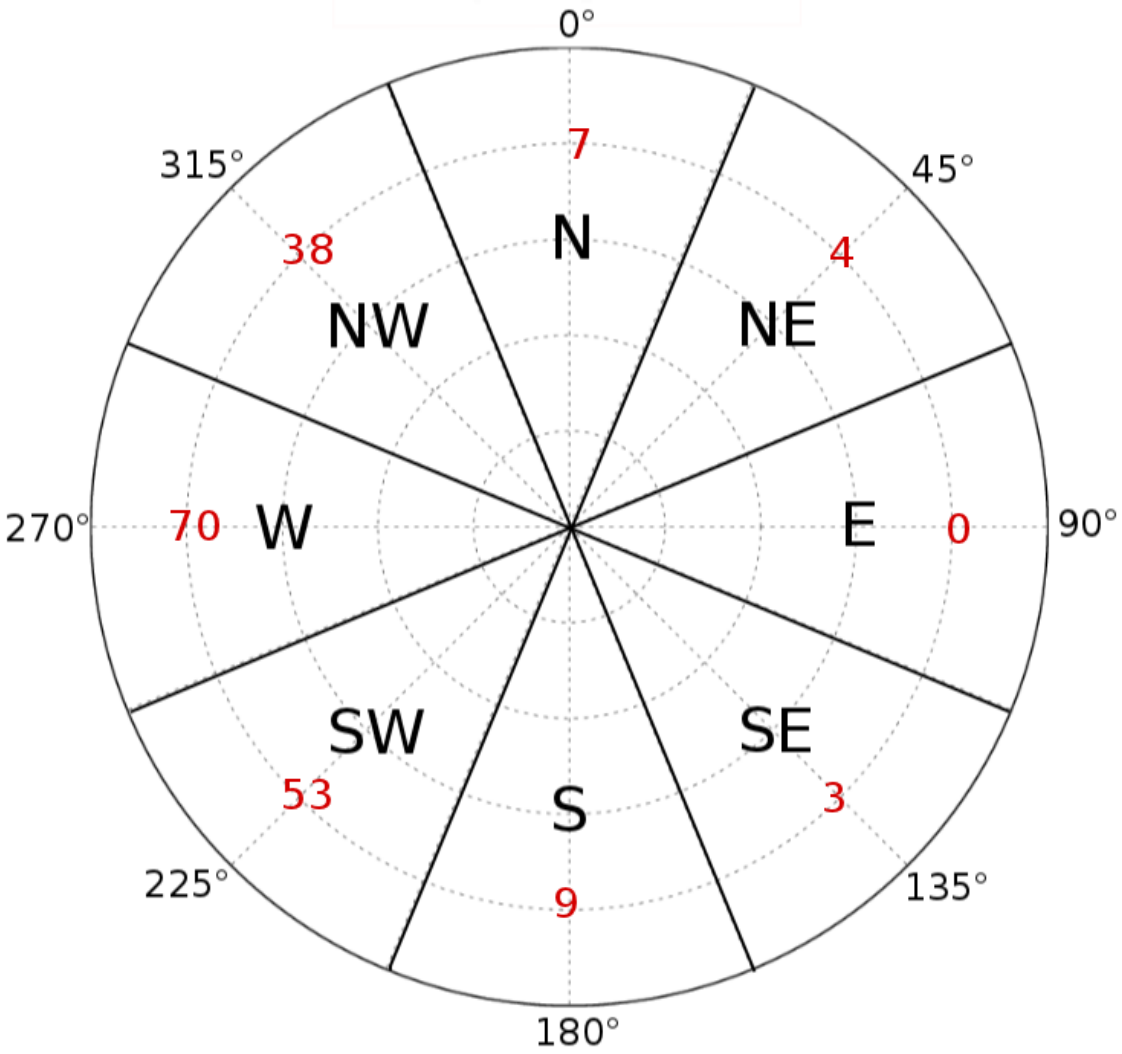


Cases were sorted by magnitude from largest to smallest

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

n=185

Cases were sorted by Wind Direction



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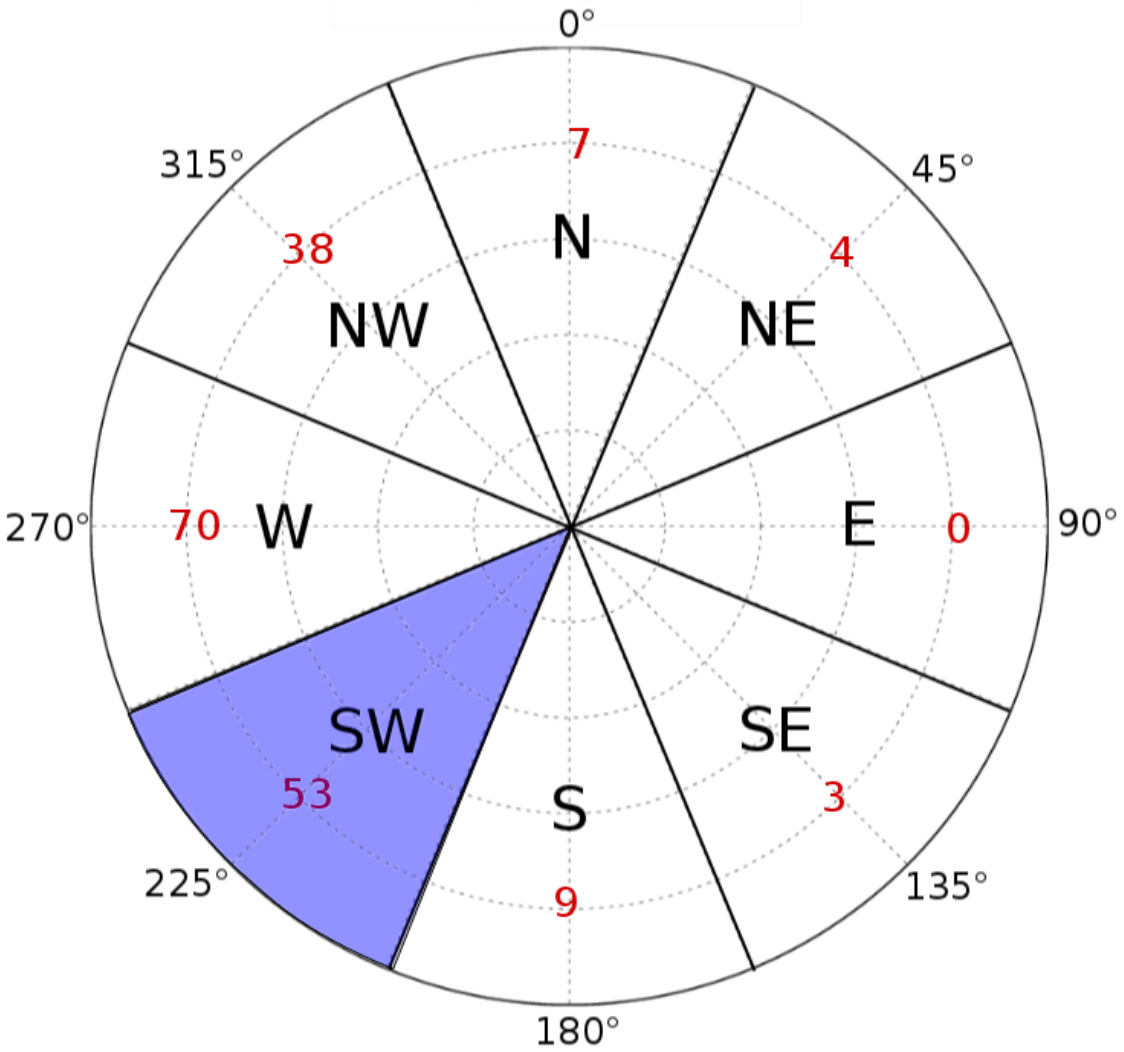
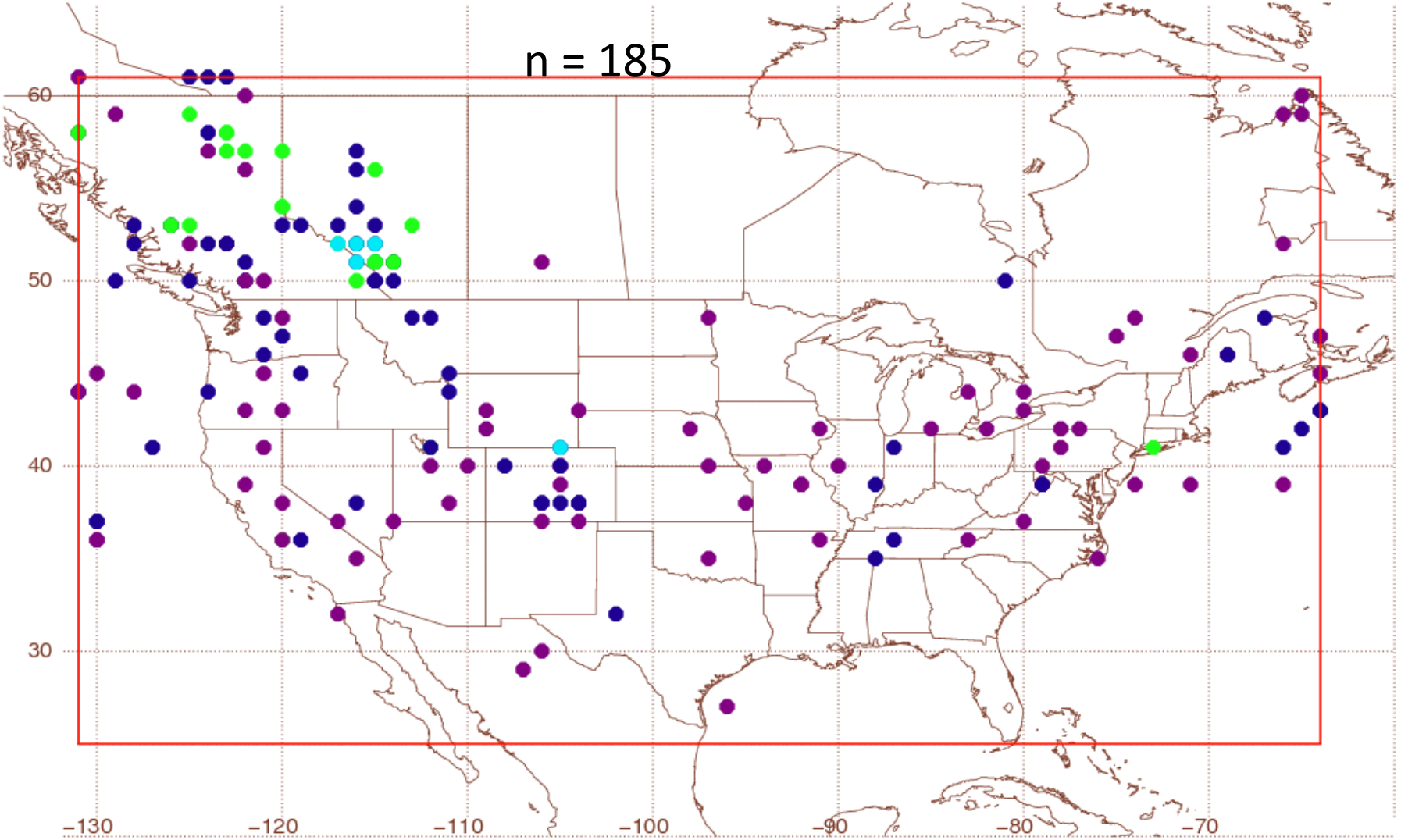


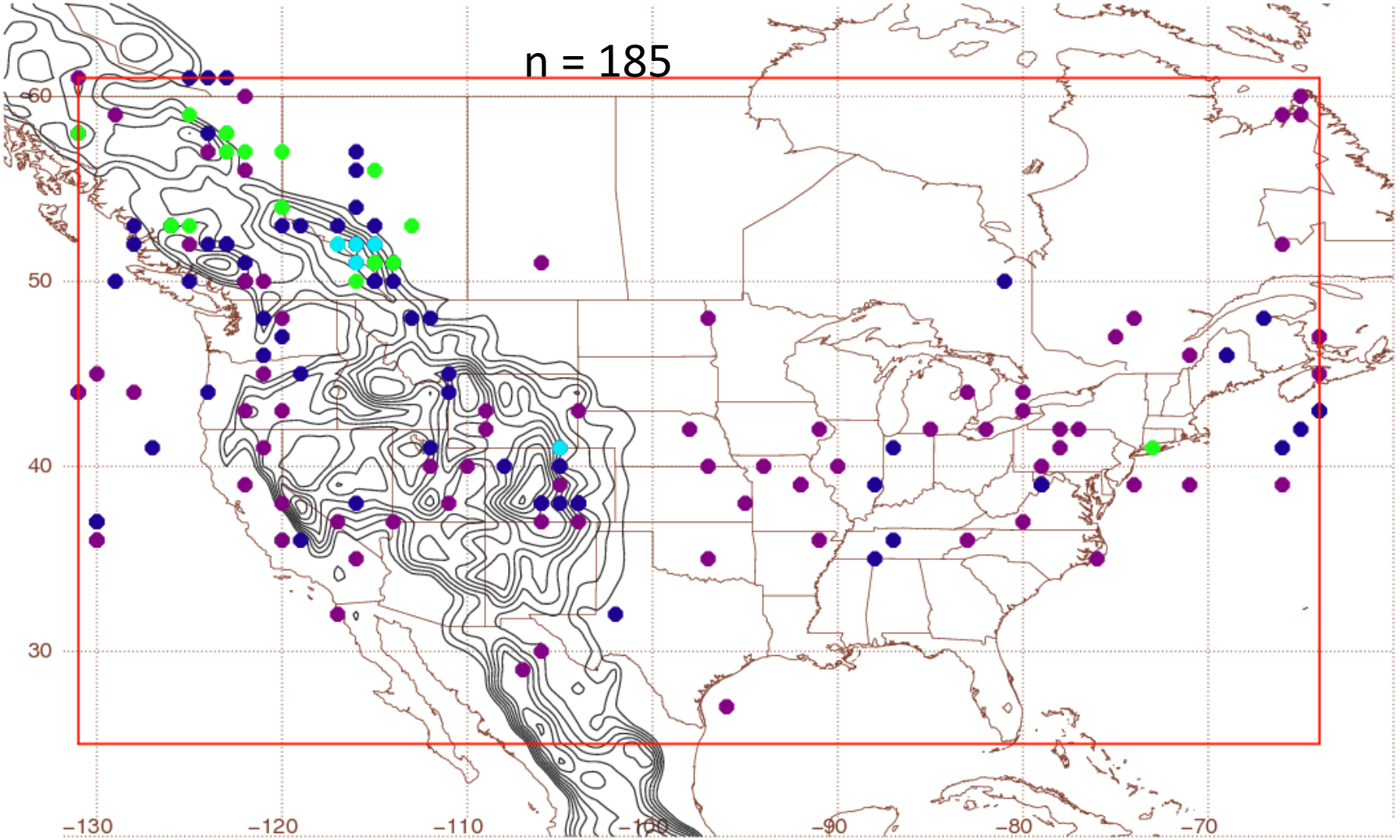
Location of all cases color coded by magnitude



>= 15K 100km^{-1}
>= 12K 100km^{-1}

>= 9K 100km^{-1}
>= 6K 100km^{-1}

Location of all cases color coded by magnitude



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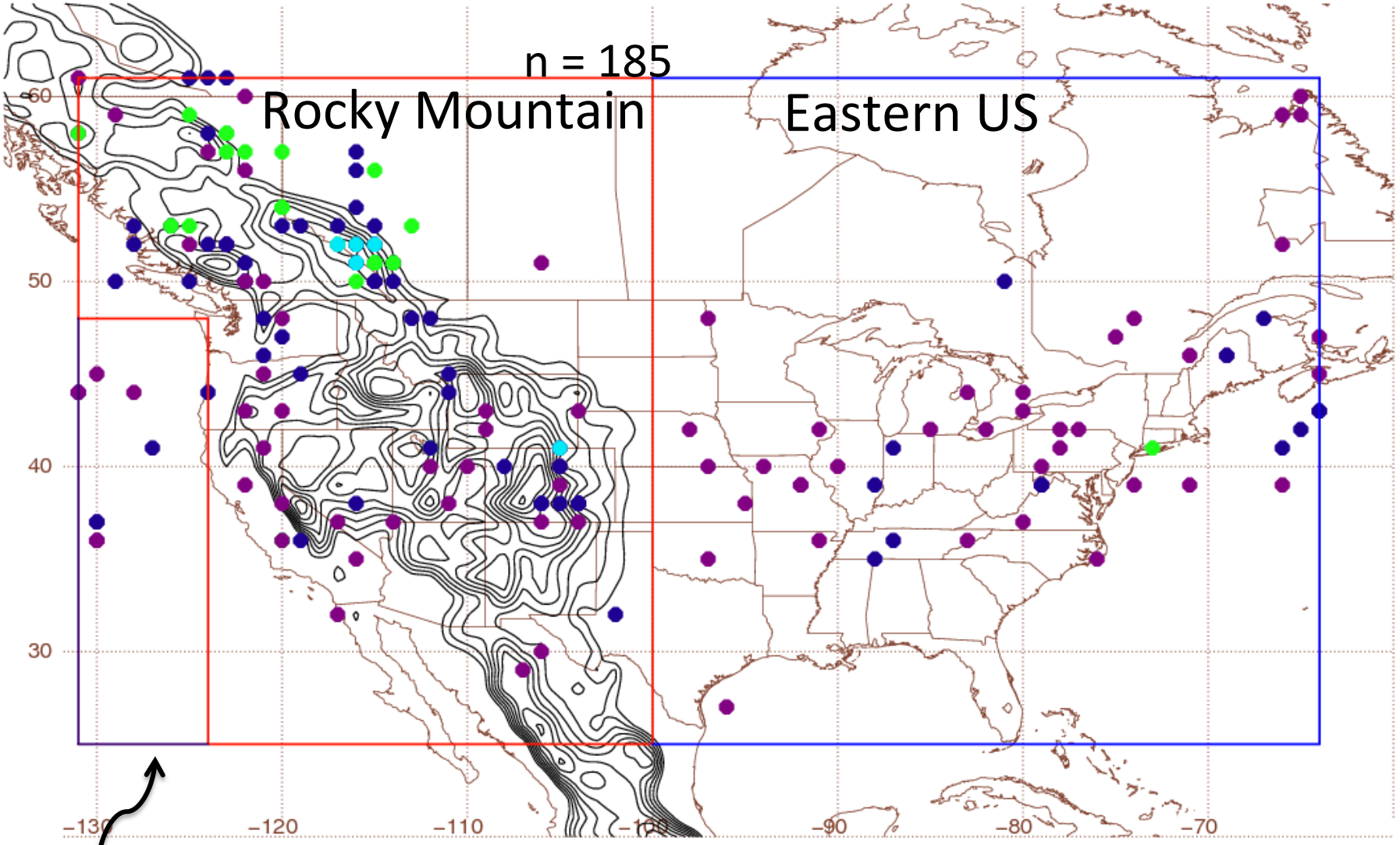

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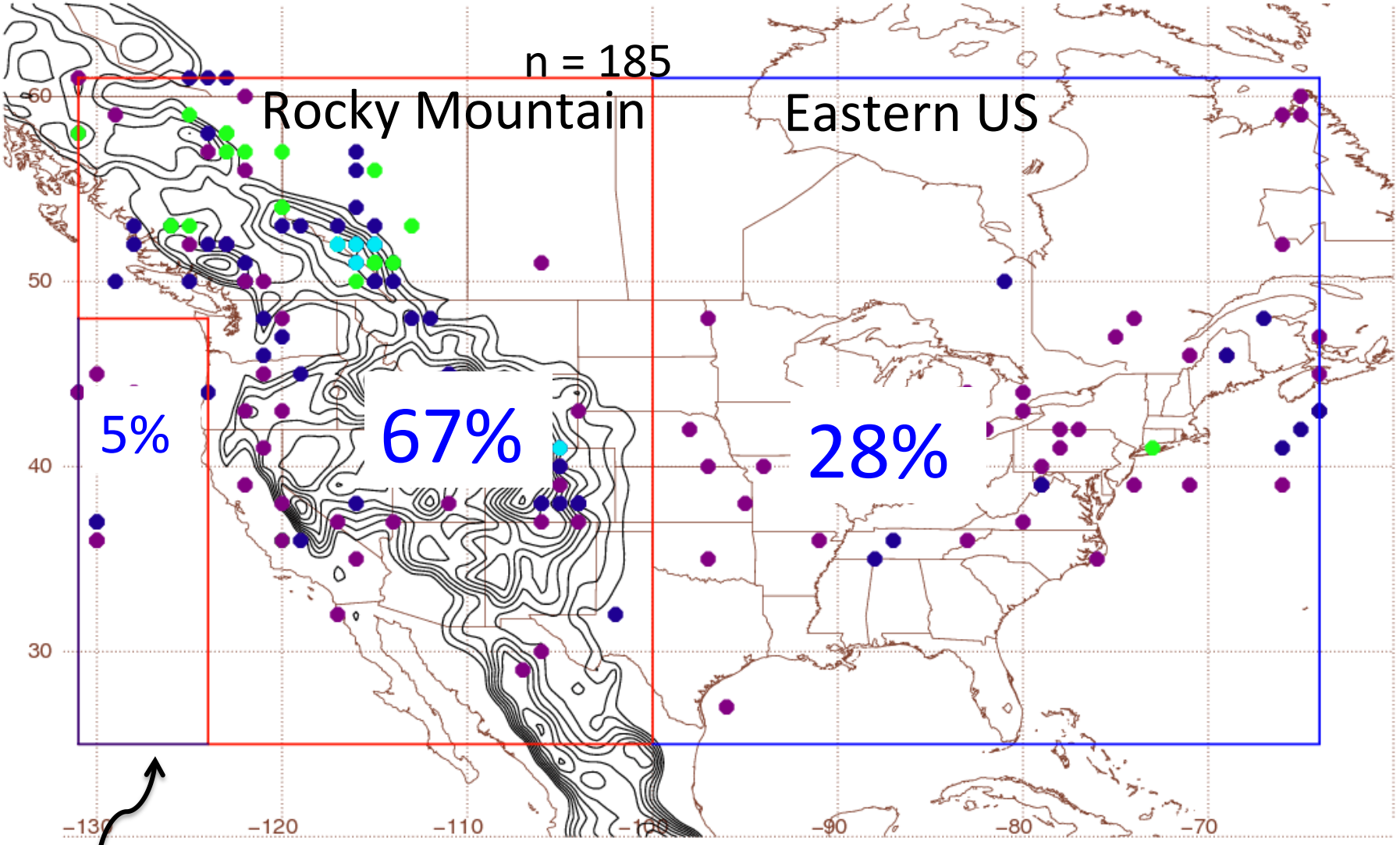

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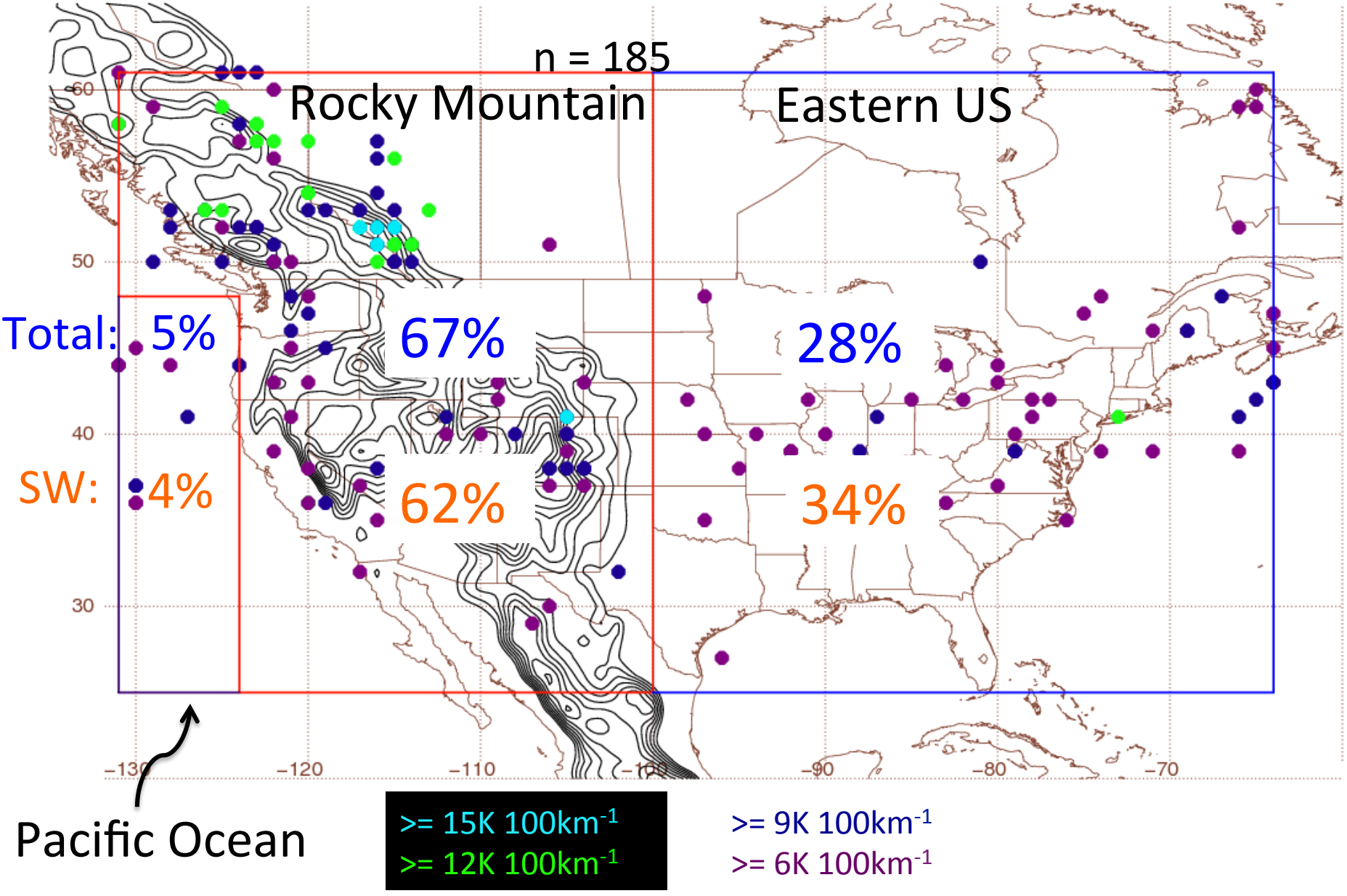
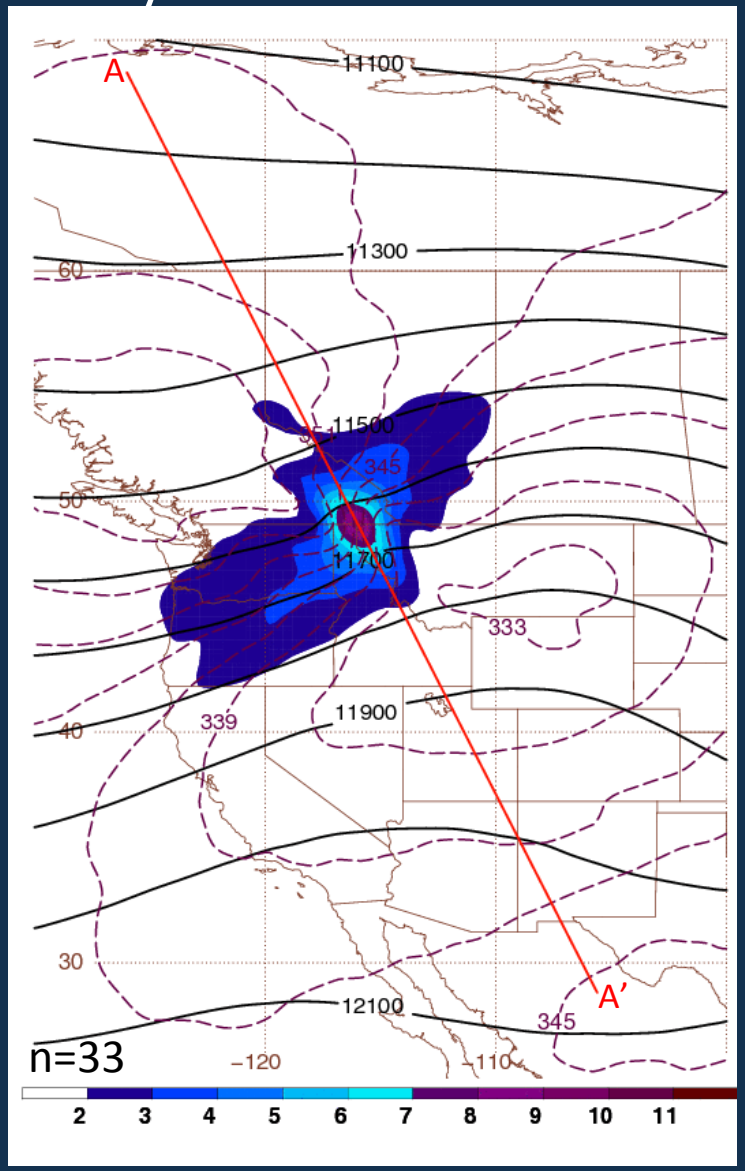


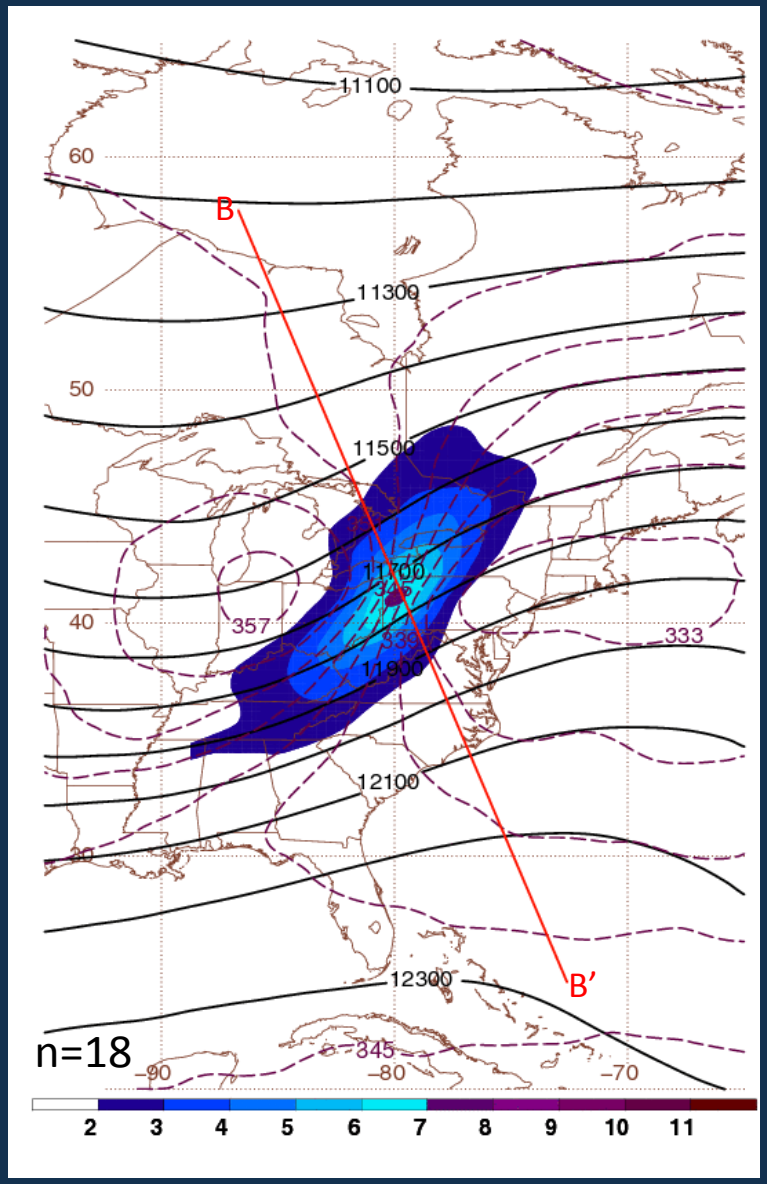
SW Composites
Rocky Mountain
vs.
Eastern US

200 hPa Front

Rocky Mountain

East Coast

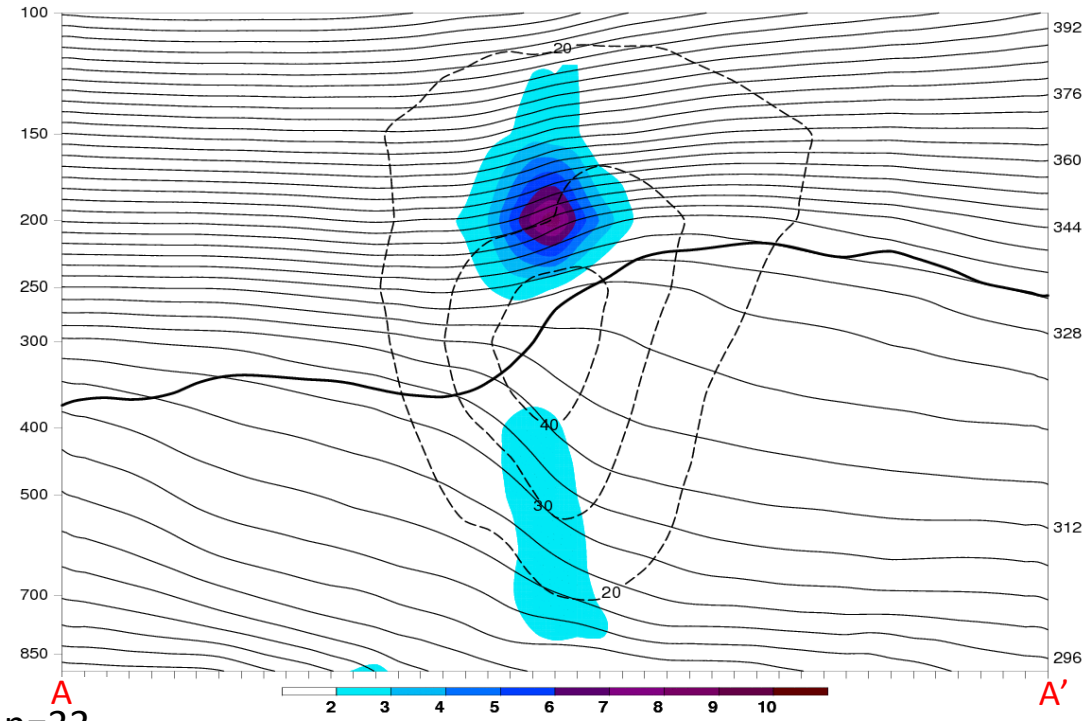




Geopotential height lines in black every 100 m; isentropes in purple dashed every 3 K; Magnitude of the potential temperature gradient shaded every 1 K/100km starting at 4 K/100km

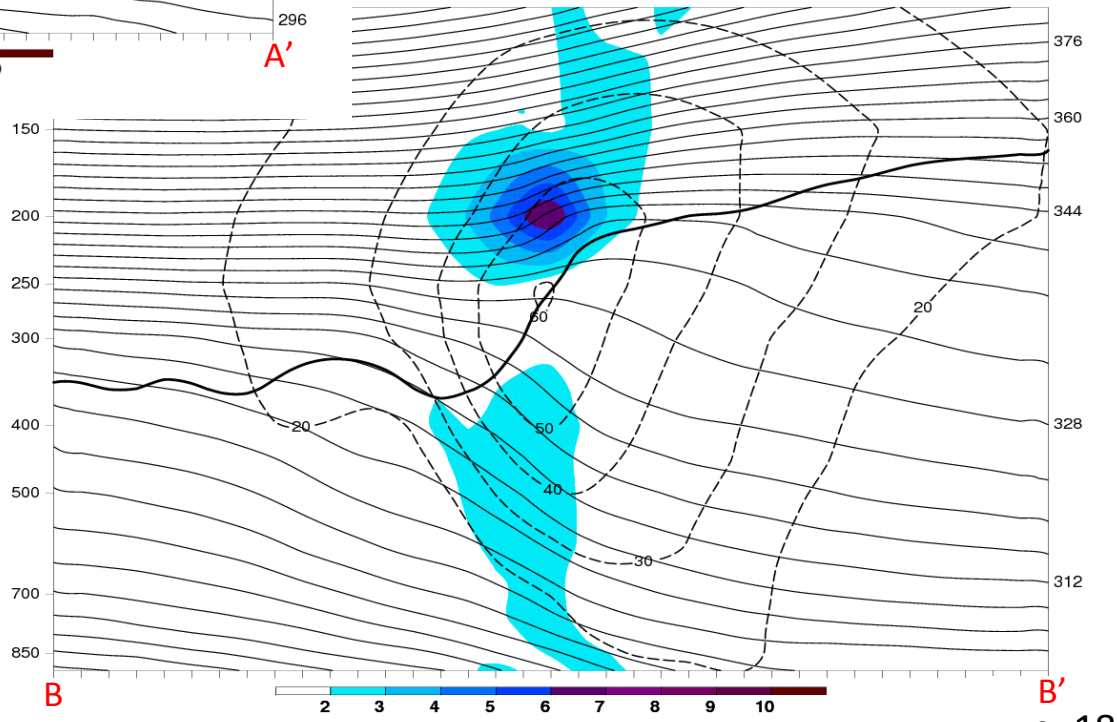
Rocky Mountains

East Coast



n=33

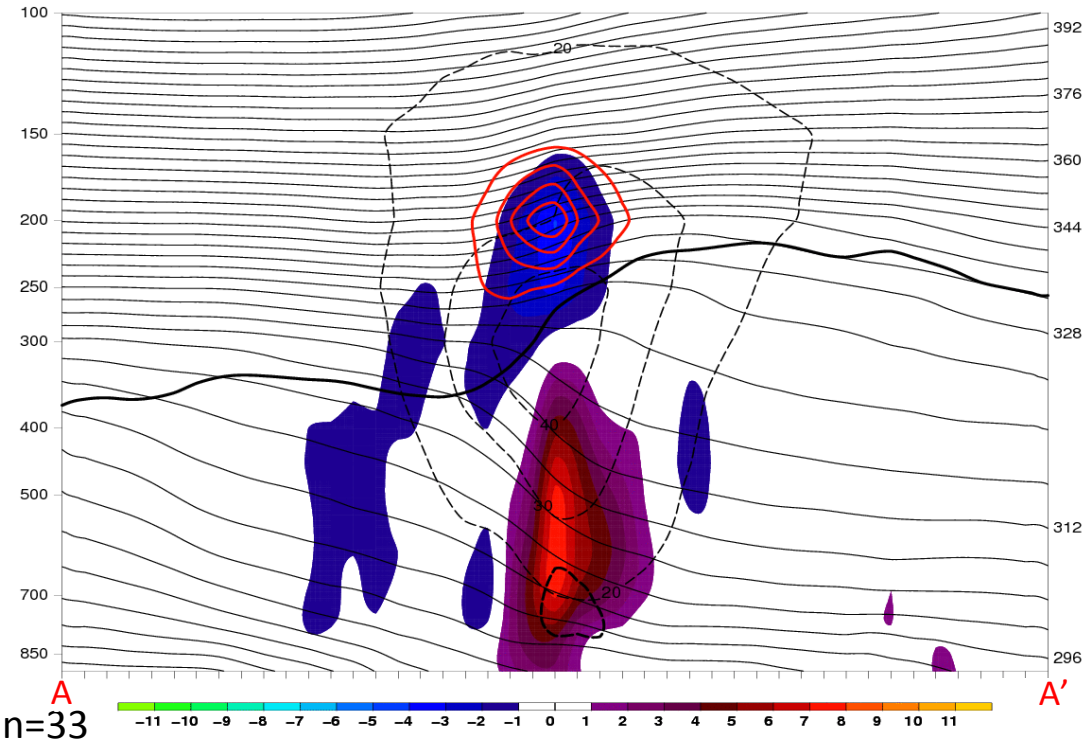
- Potential temperature: thin black lines in K
- Magnitude of the wind: dashed black in m s^{-1}
- Magnitude of the potential temperature gradient in K 100
- km^{-1}
- 1.5 PVU: dark black line



n=18

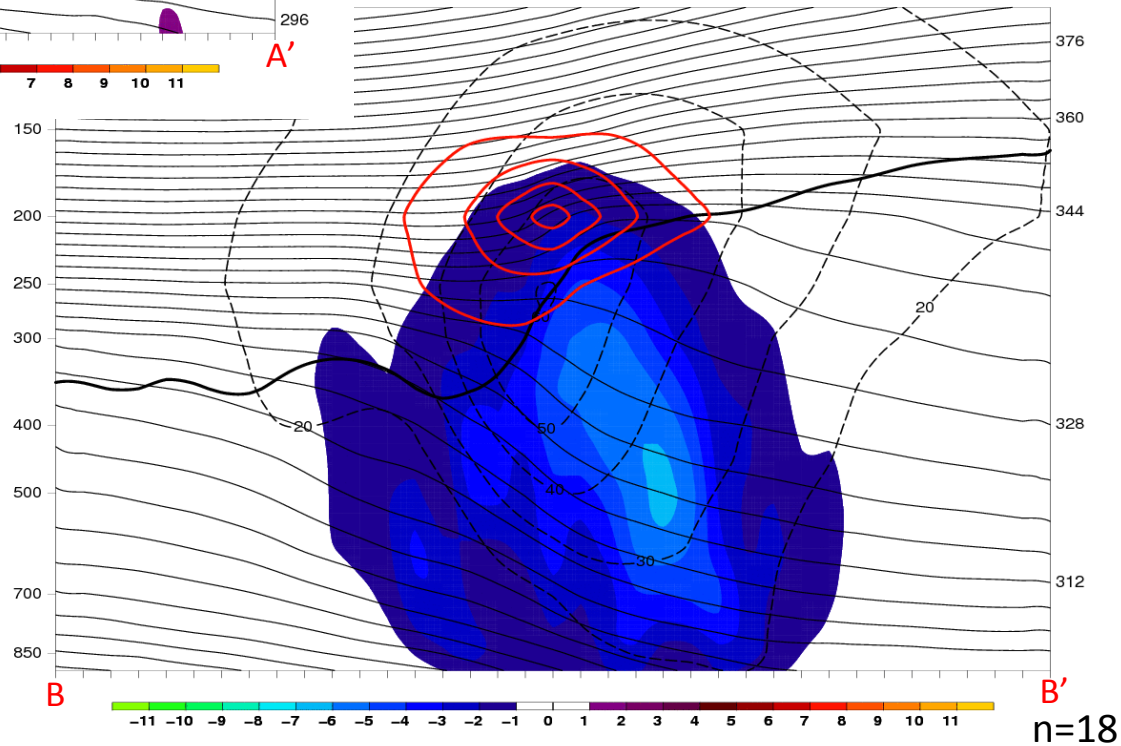
Rocky Mountains

East Coast



n=33

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



n=18

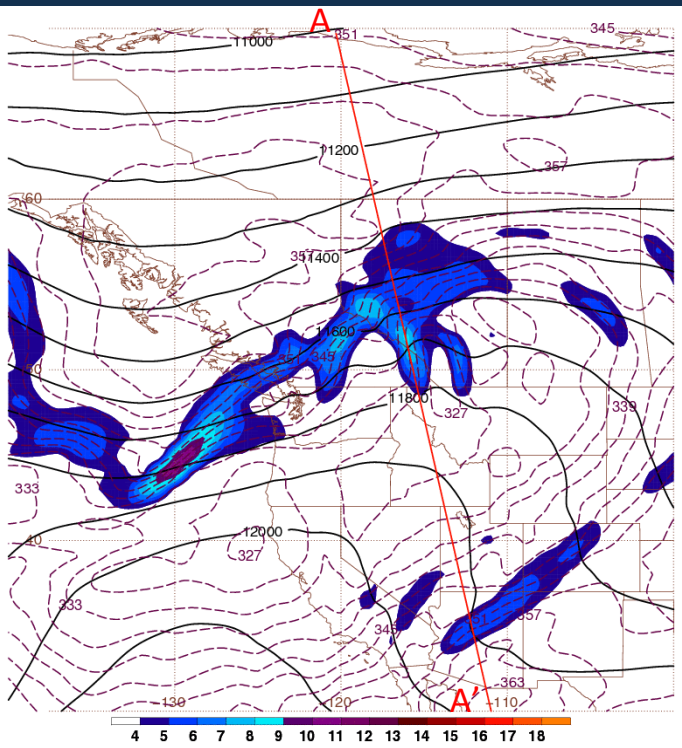
CASE STUDY: SW

Rocky Mountain Case:

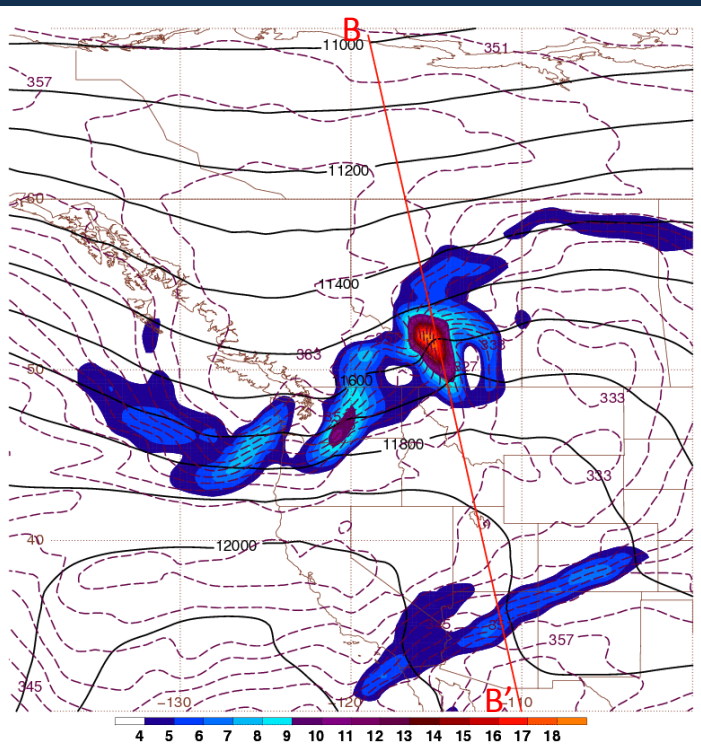
0000 UTC 15 January 2008

200 hPa

t-6h



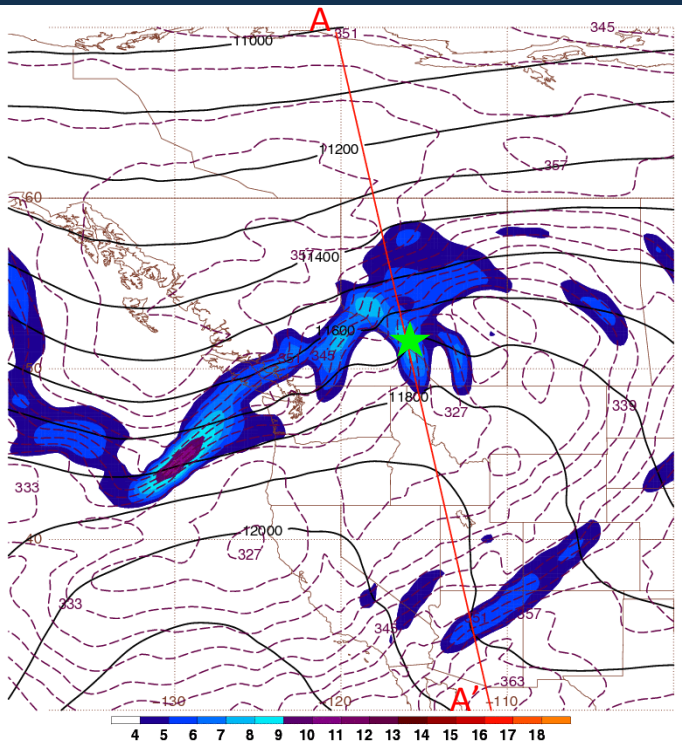
t-0



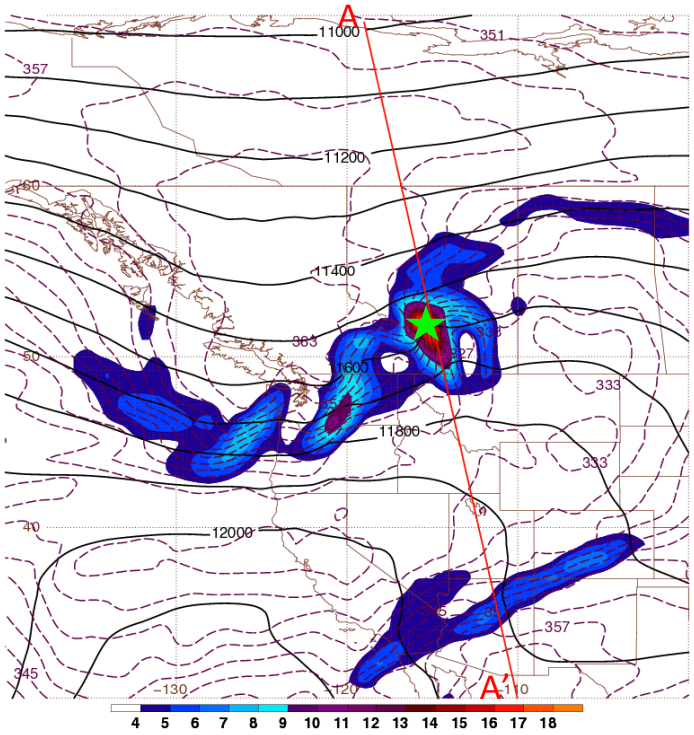
- 200-hPa geopotential height lines in black
- Isentropes in purple dashed every 3 K
- Magnitude of the potential temperature gradient shaded

200 hPa

t-6h



t-0



- 200-hPa geopotential height lines in black
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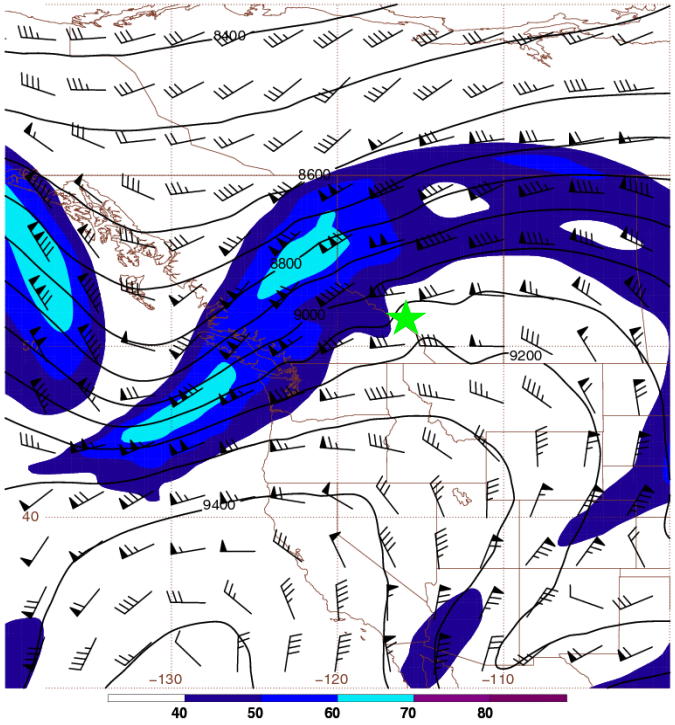
- Magnitude of the potential temperature gradient shaded

0000 UTC 15 January 2008
Rocky Mountain Case

300 hPa

t-6h



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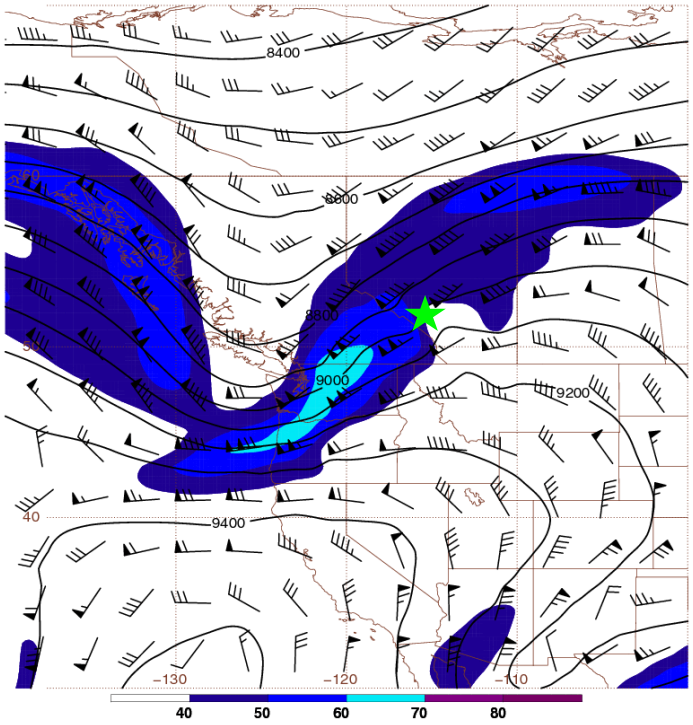


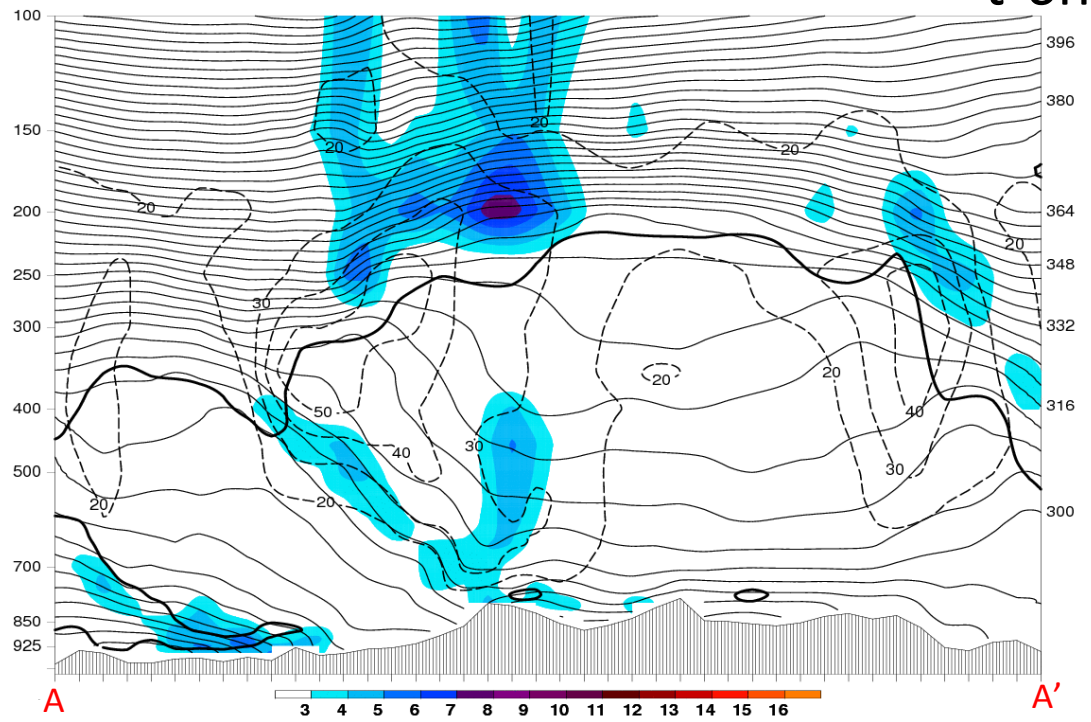
- 300-hPa geopotential height lines in black
- Magnitude of the wind speed shaded
- Wind barbs in knots.

Cross Sections

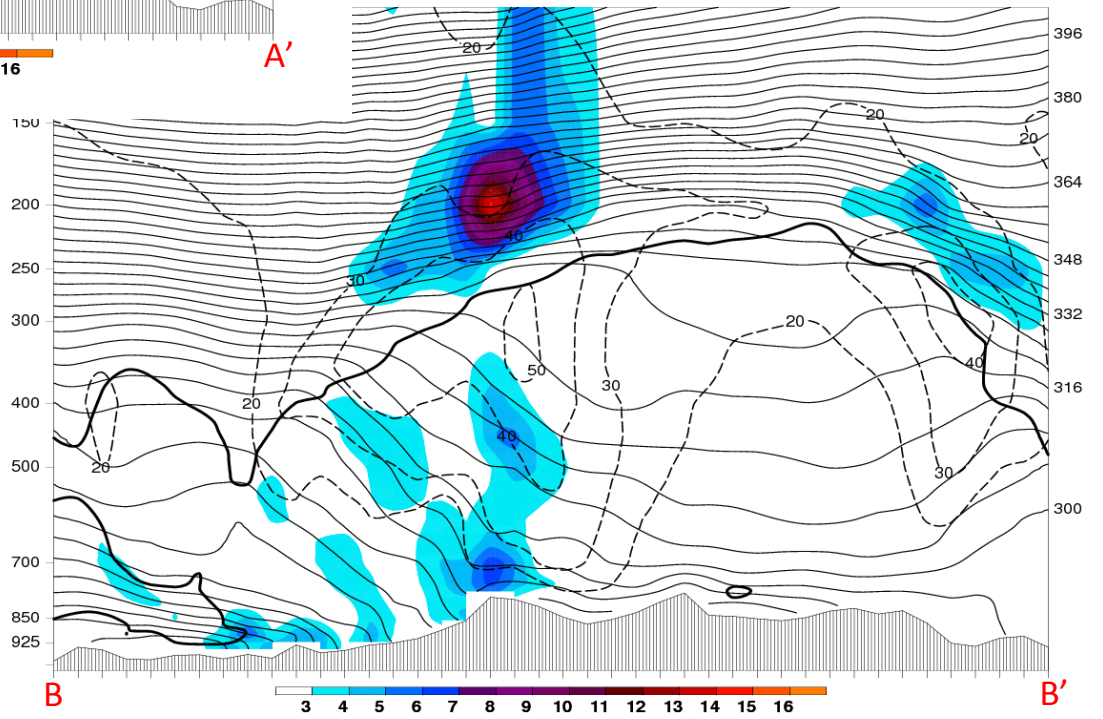
0000 UTC 15 January 2008

Rocky Mountain Case

t-6h



t-0



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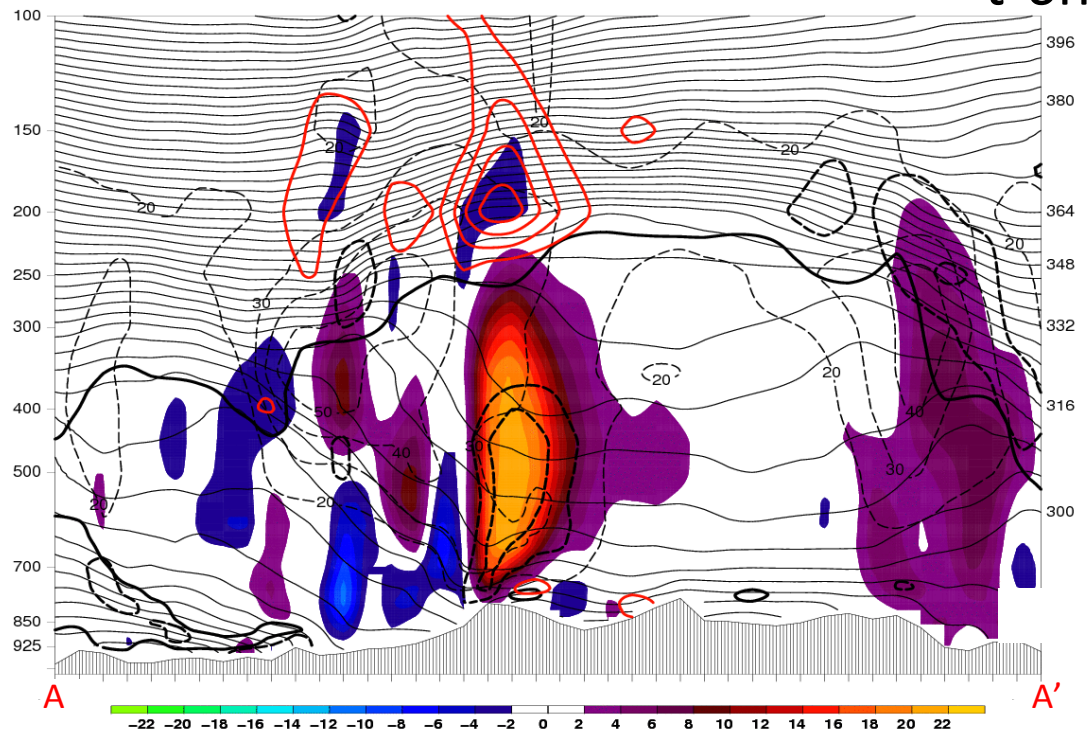
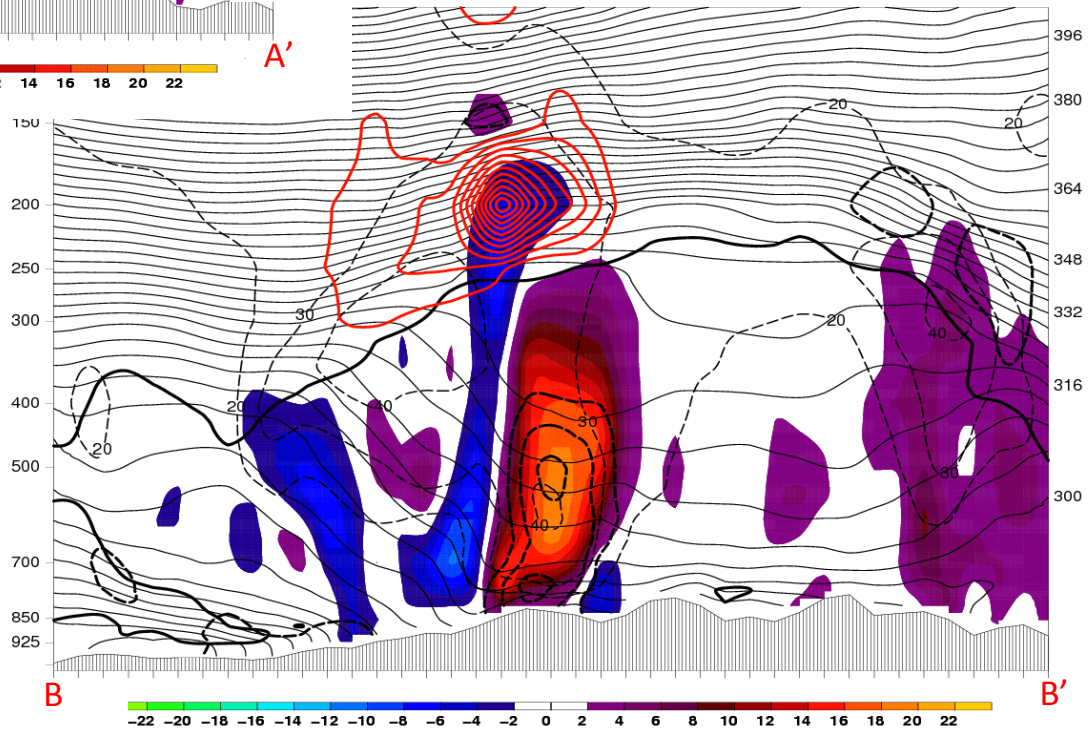
Rocky Mountain Case

t-6h



t-0



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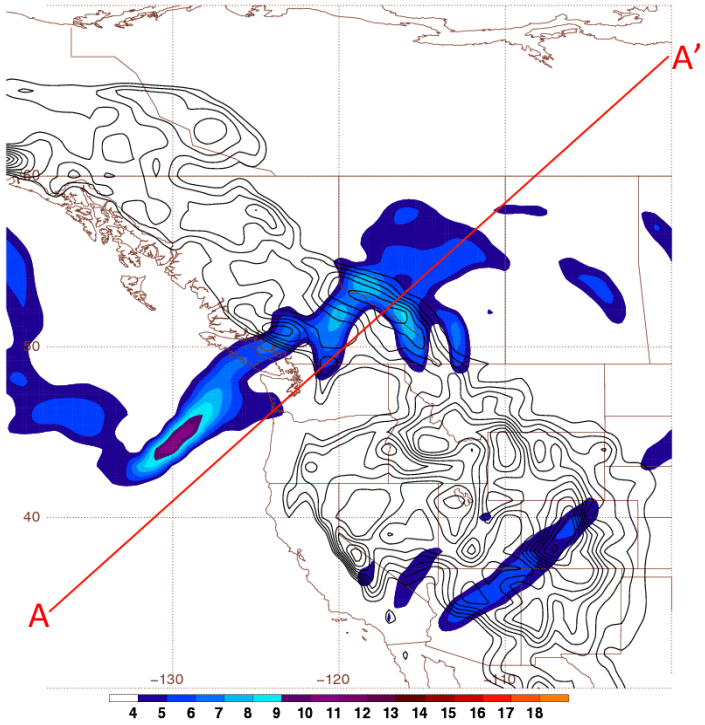
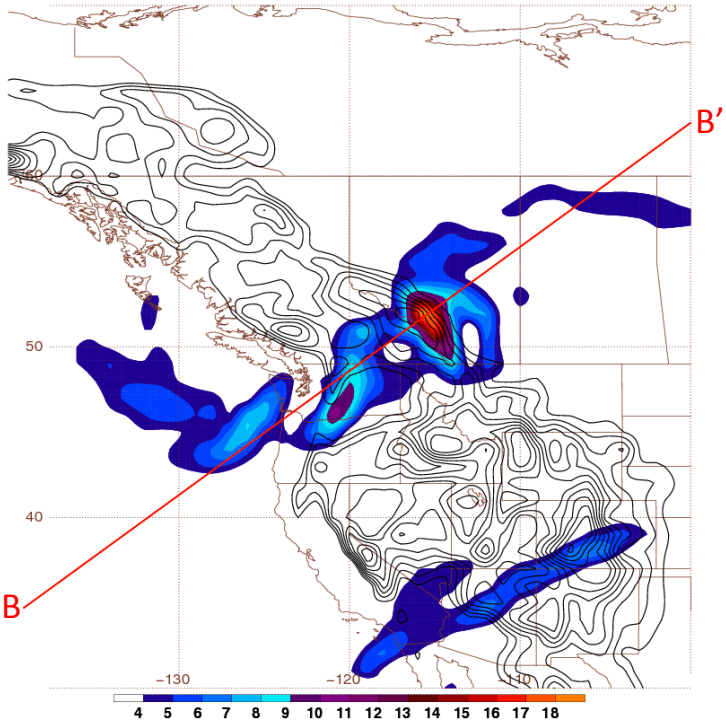
200 hPa

T-6h



T-0

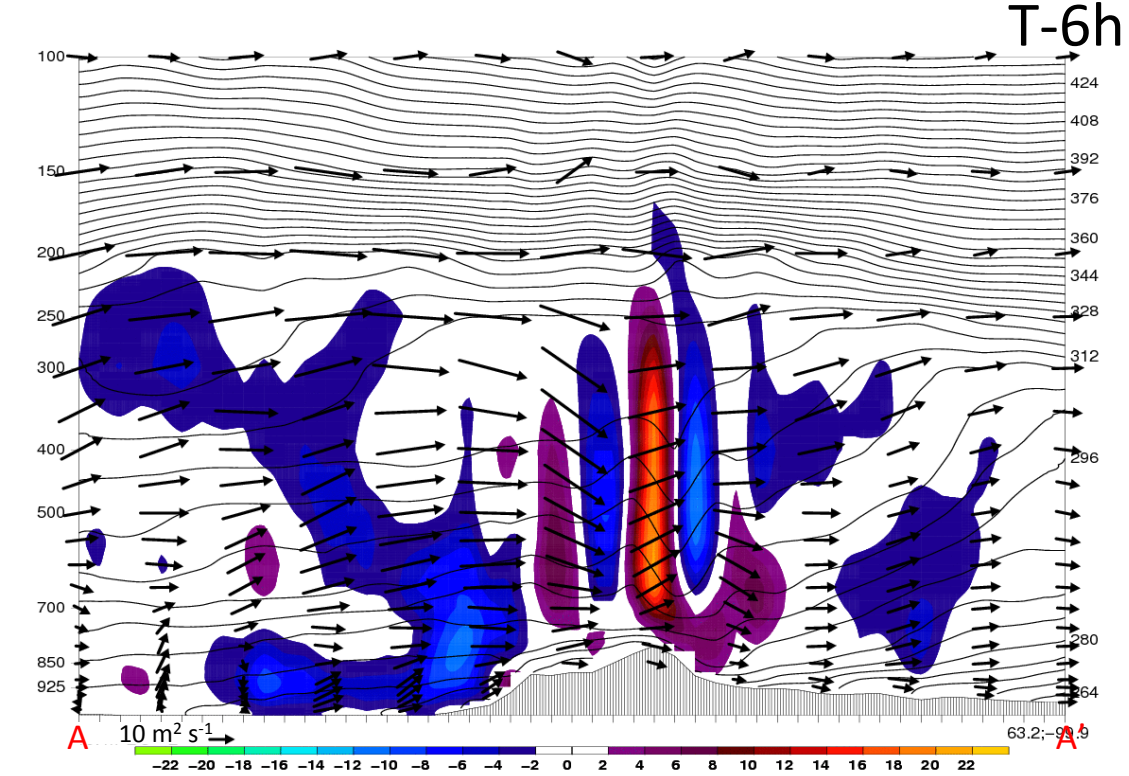


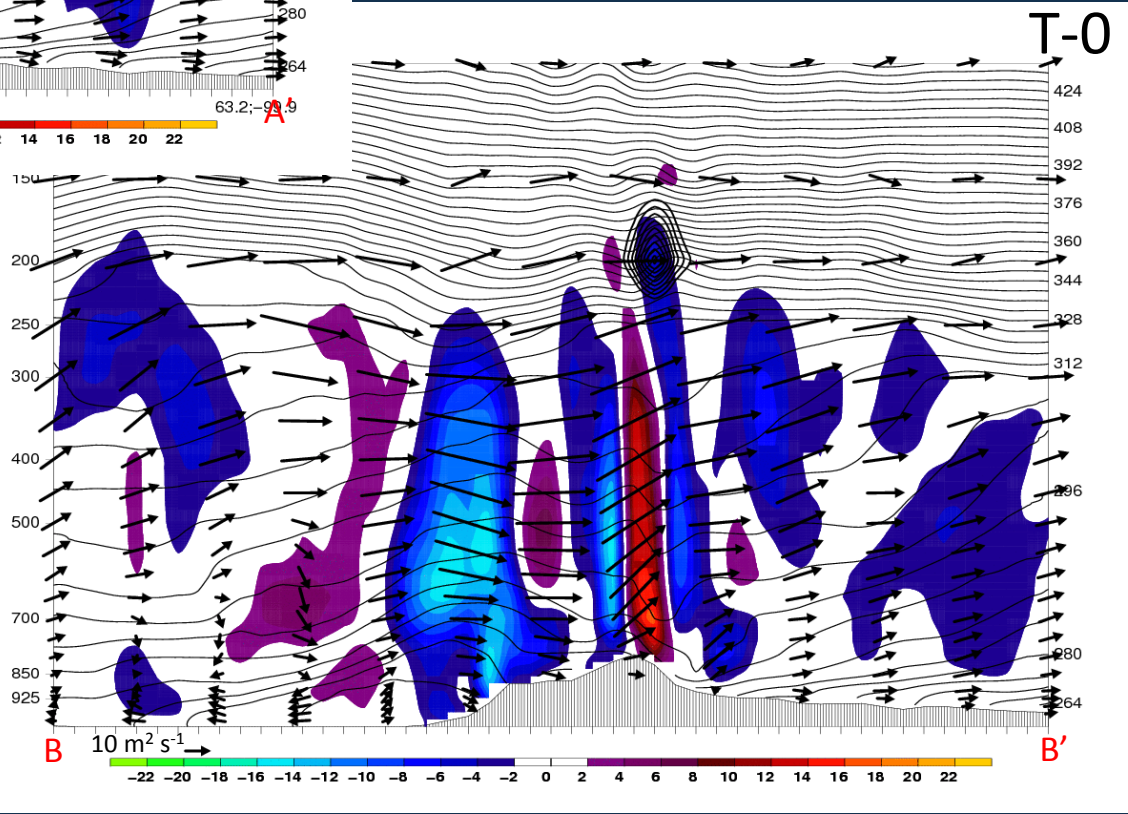
- 200-hPa Potential temperature gradient shaded
- Surface height every 200 m starting at 1000m in black

Cross Sections

0000 UTC 15 January 2008

Rocky Mountain Case





- Potential temperature: thin black lines in K
- Vertical motion every $1x10^{-3}$ hPa s^{-1} : shaded
- Circulation: arrows
- LSF: thick black lines
- 1.5 PVU: dark black line

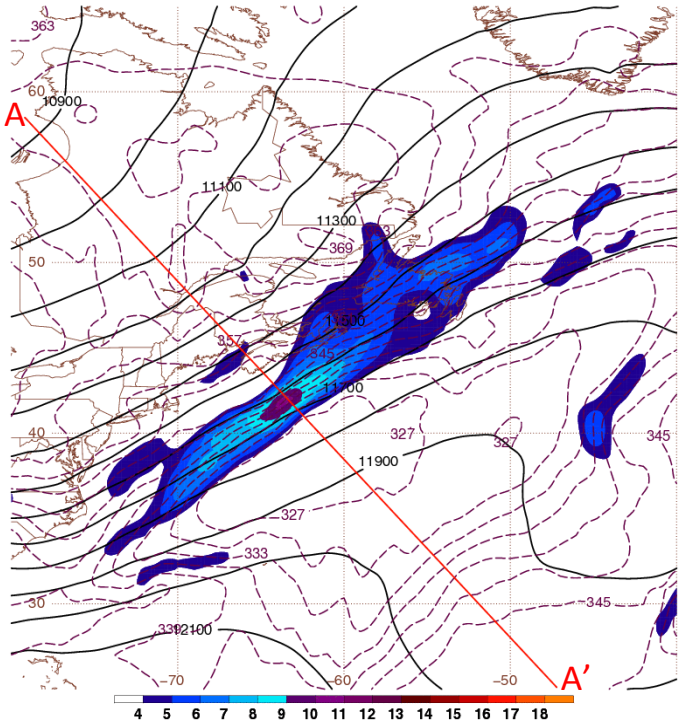
CASE STUDY: SW

Eastern US Case:

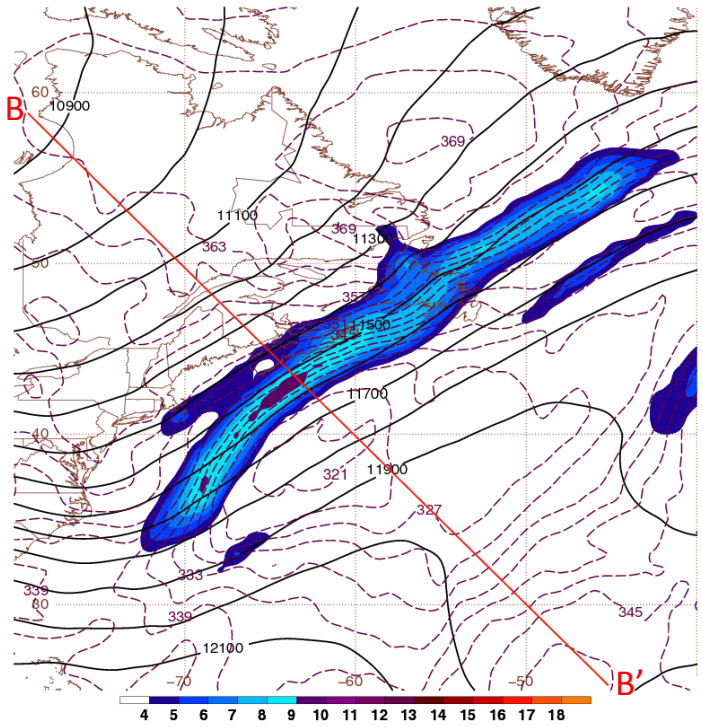
1200 UTC 19 January 2012

200 hPa

T-6h



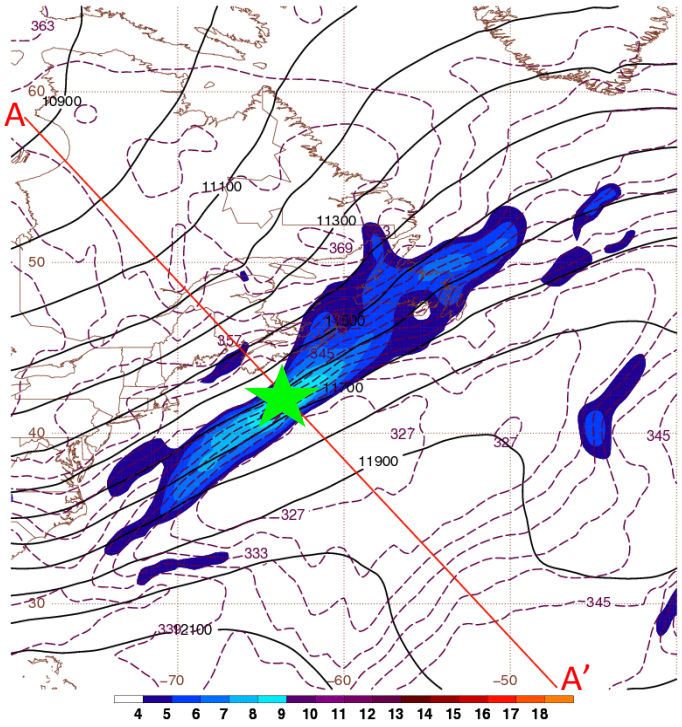
T-0



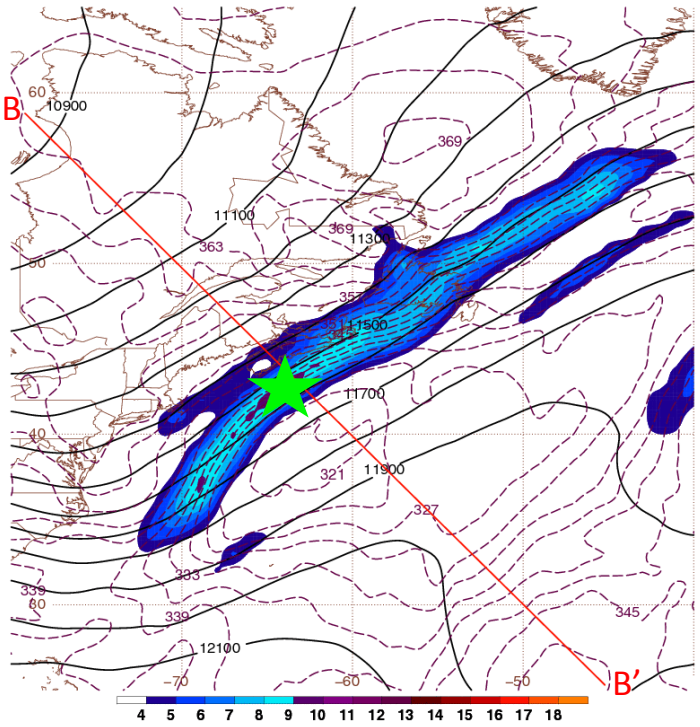
- 200-hPa geopotential height lines in black
- Isentropes in purple dashed every 3 K
- Magnitude of the potential temperature gradient shaded

200 hPa

T-6h



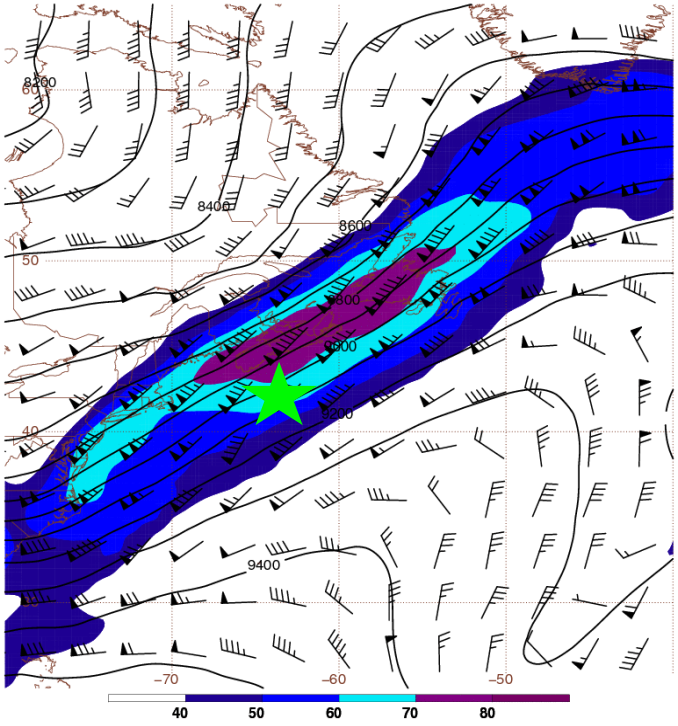
T-0



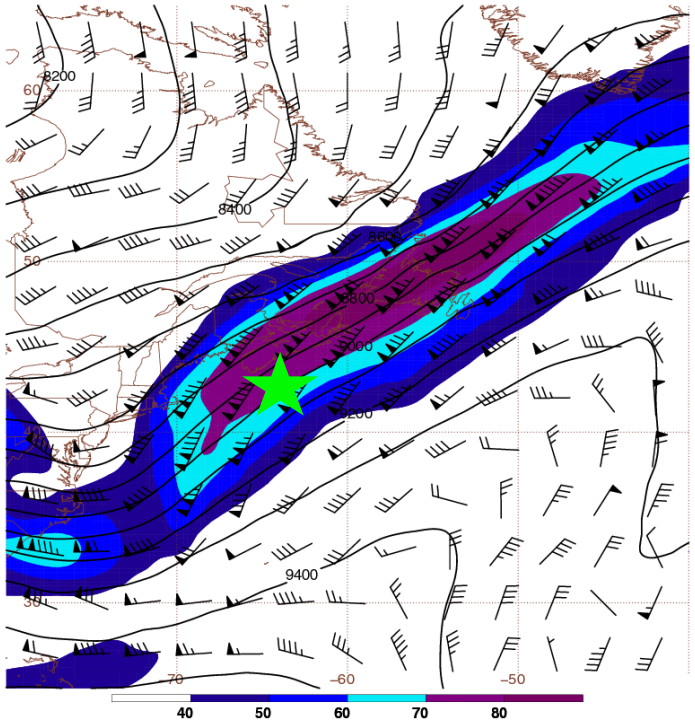
- 200-hPa geopotential height lines in black
- Isentropes in purple dashed every 3 K
- Magnitude of the potential temperature gradient shaded

300 hPa

T-6h



T-0



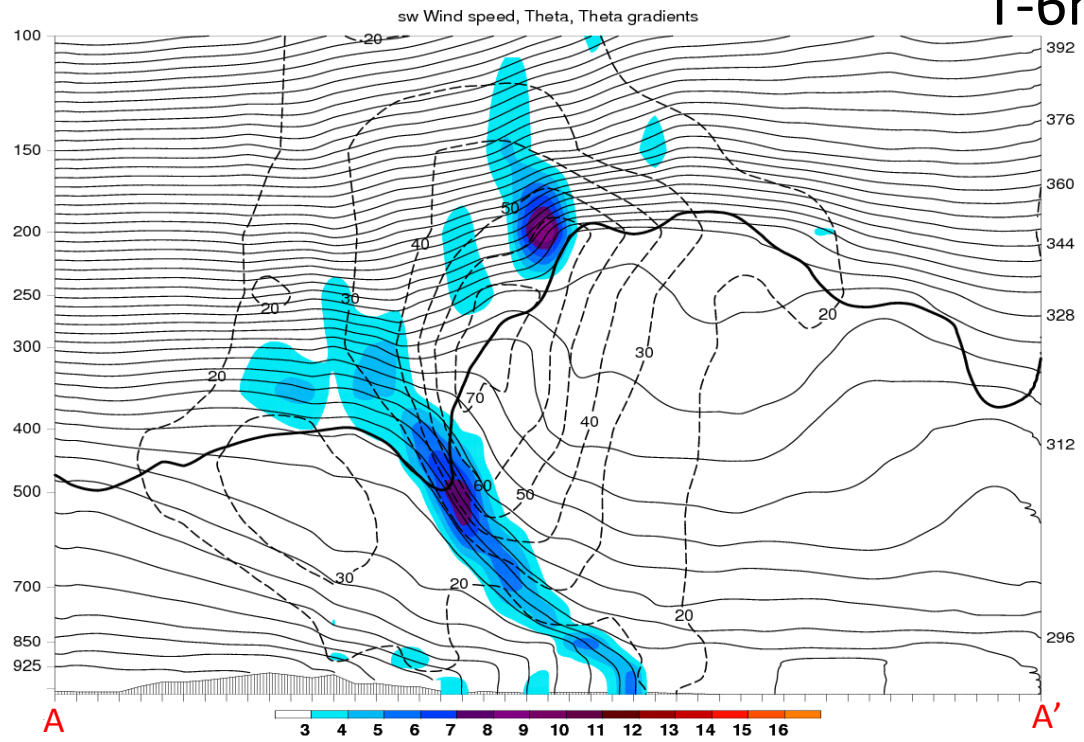
- 300-hPa geopotential height lines in black
- Magnitude of the wind speed shaded
- Wind barbs in knots.

Cross Sections

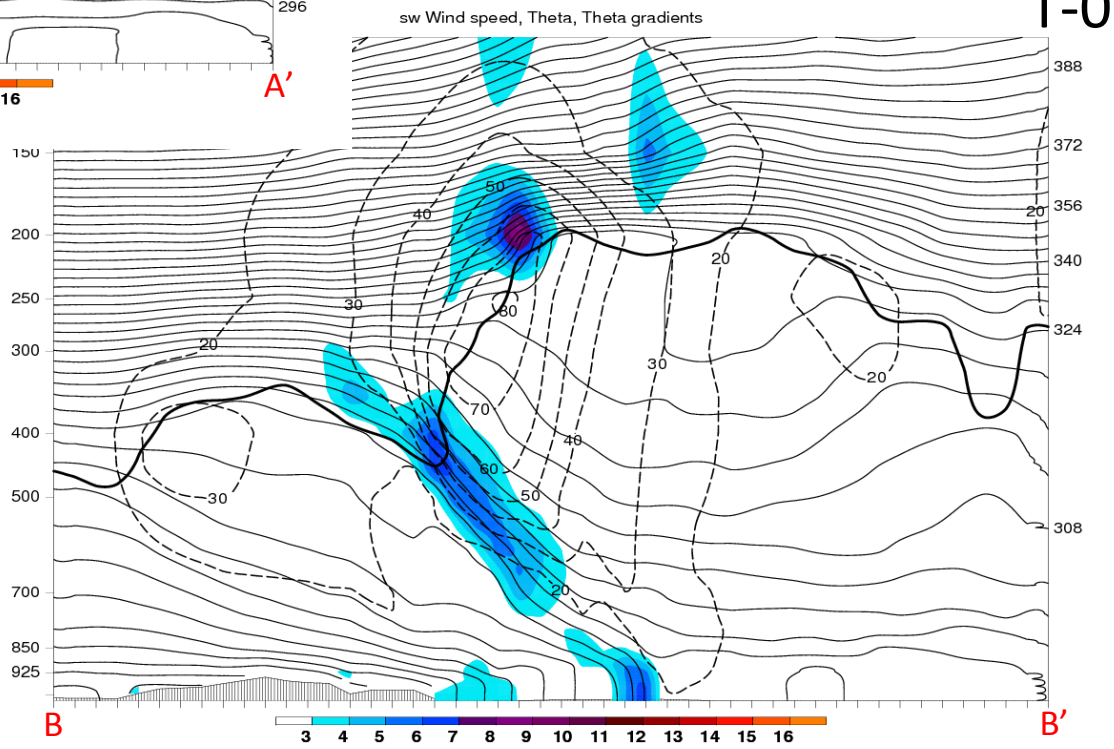
1200 UTC 19 January 2012

East Coast Case

T-6h



T-0

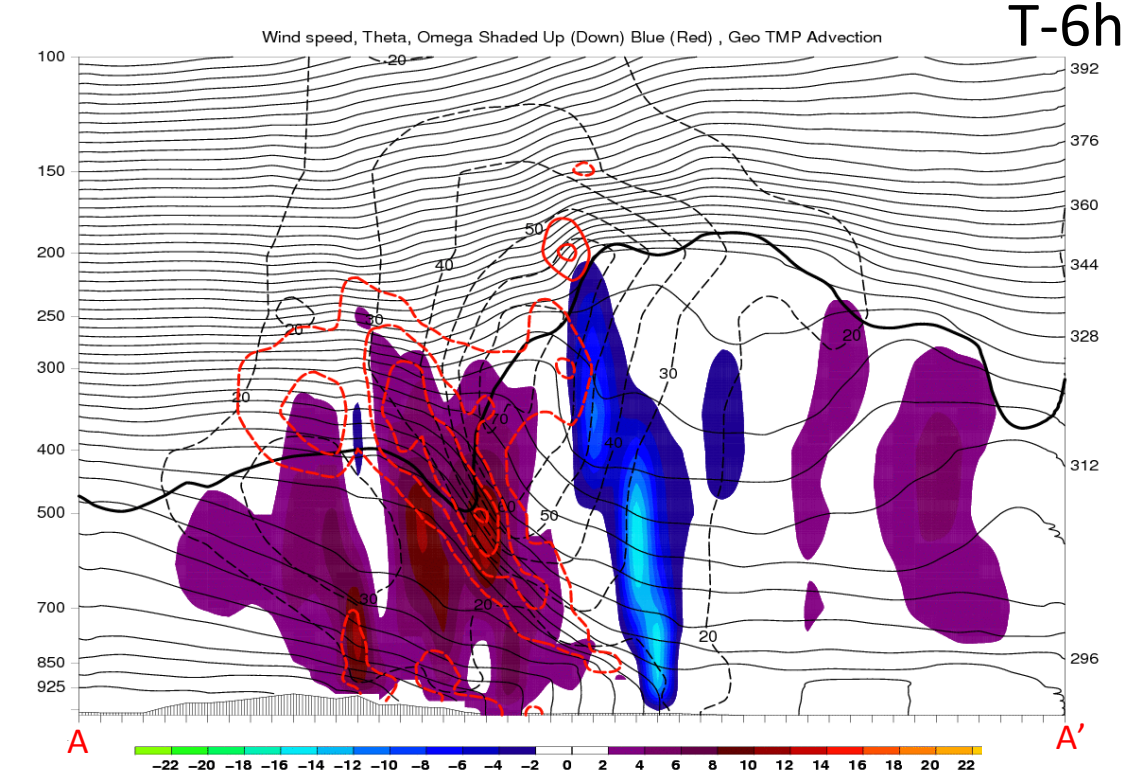


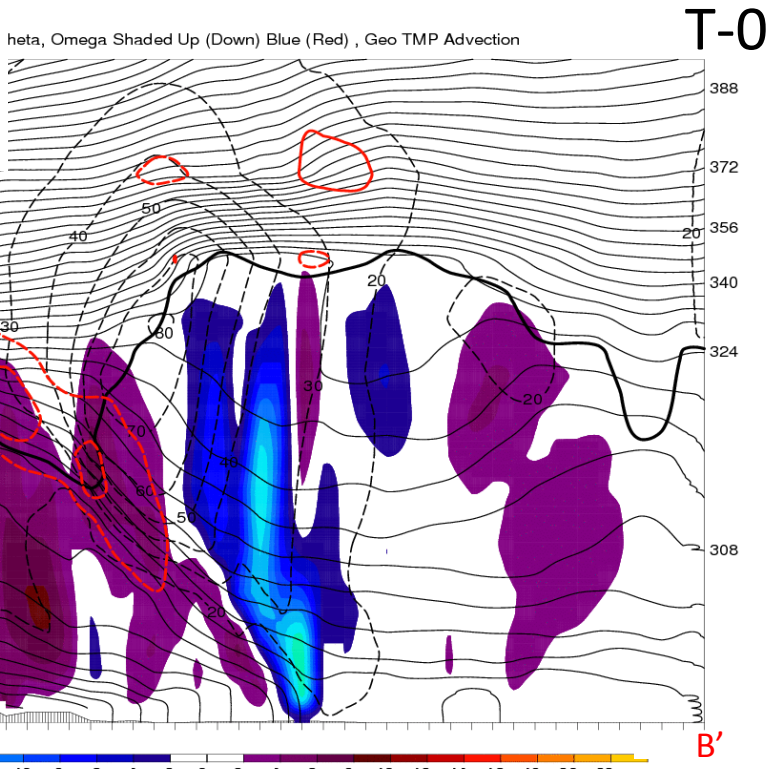
- Potential temperature: thin black lines in K
- Magnitude of the wind: dashed black in m s^{-1}
- Magnitude of the potential temperature gradient in K 100
- km^{-1}
- 1.5 PVU: dark black line

Cross Sections

1200 UTC 19 January 2012

East Coast Case





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

Conclusions

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

Conclusions

- **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