Synoptic-Scale Analysis of Freezing Rain Events in Montreal, Quebec

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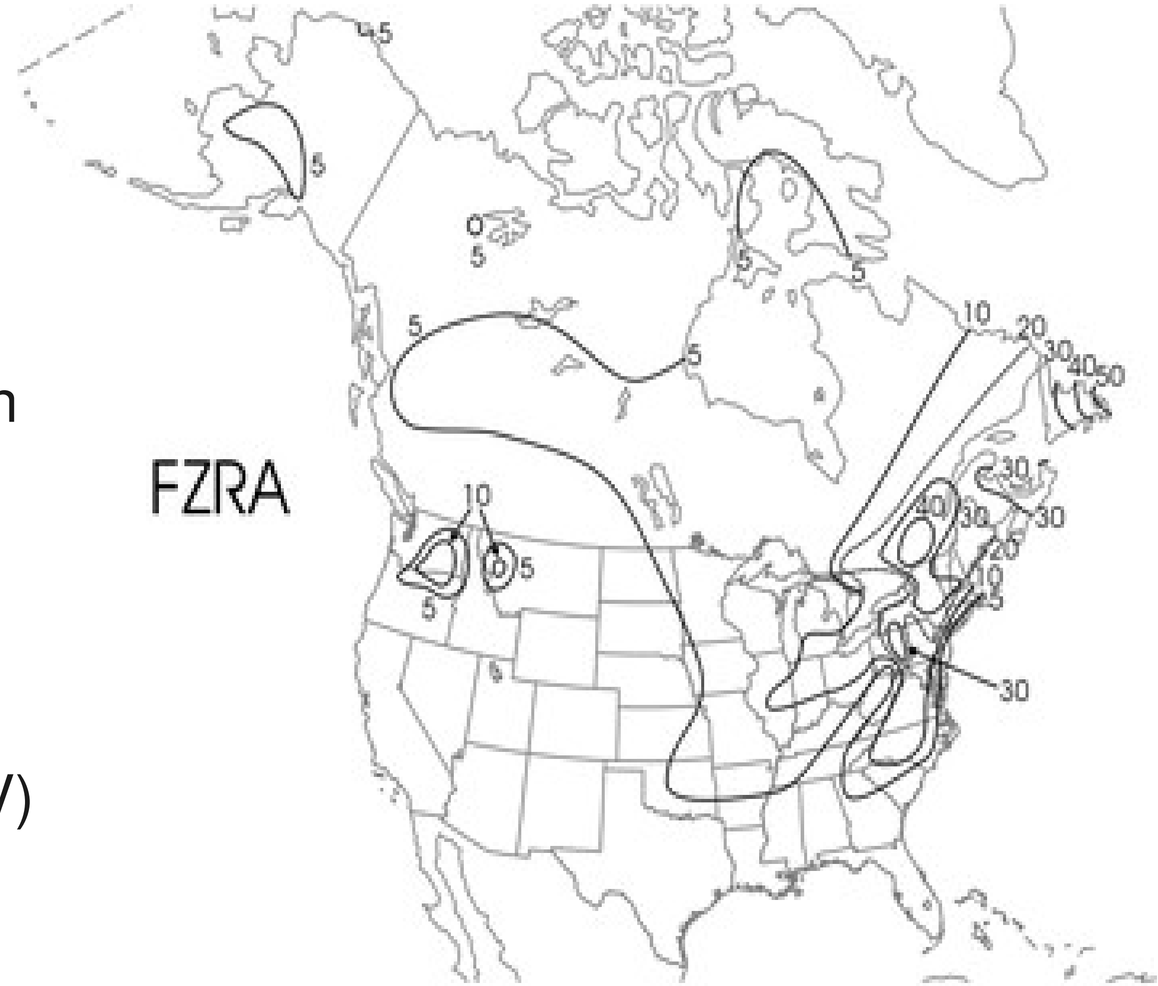
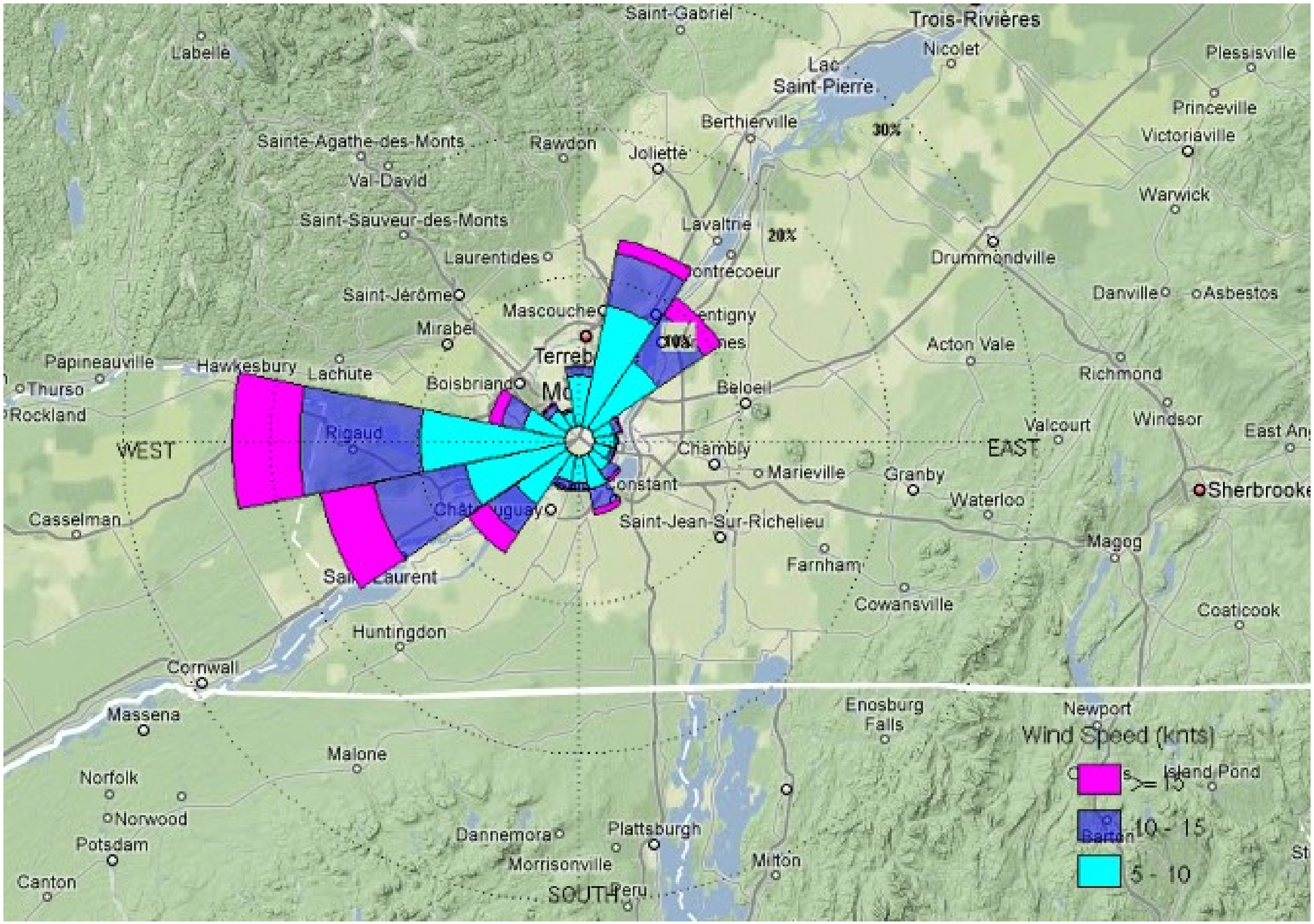
Motivation

- Freezing rain is a major environmental hazard in eastern Canada/US
  - 1998 Ice Storm - $3 billion in damage, left over one million people without power
- Especially common in the St. Lawrence River Valley (SLRV)
- More insight – better forecasts



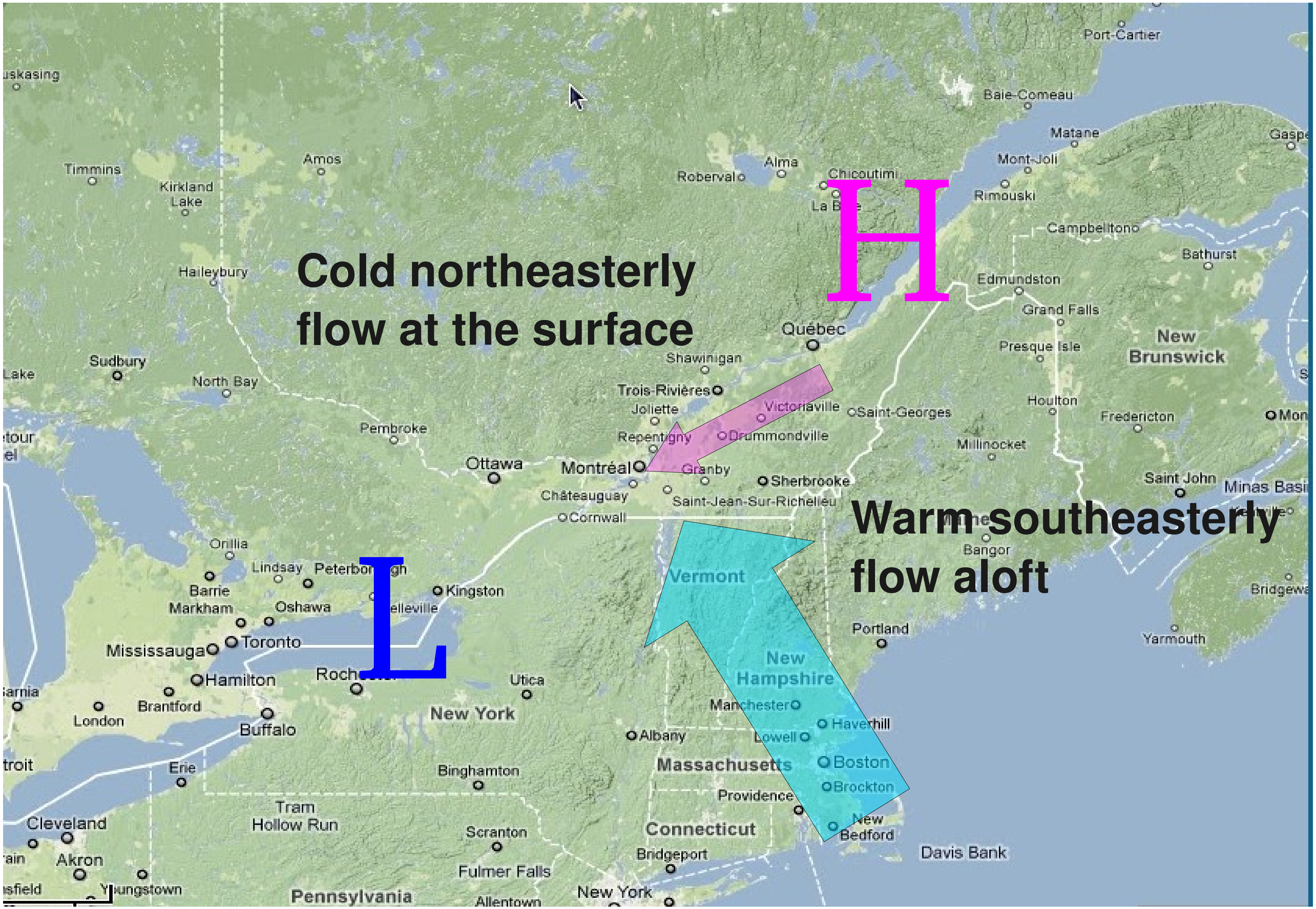
Median annual hours of freezing rain from 1979 to 1990 (Fig. 2, Cortinas et al. 2004)

DJF observed surface winds at Montreal, Quebec (YUL) 1979-2002



Courtesy of Alissa Razy

Weather Scenario for Freezing Rain



Adapted from Milton and Bourque 1999

Objectives

- Our knowledge of freezing rain at Montreal has been derived primarily from case study analyses
- Goals:
  - Construct a complete list of freezing rain events for the time period 1979-2008
  - Identify key synoptic-scale features of typical Montreal freezing rain events

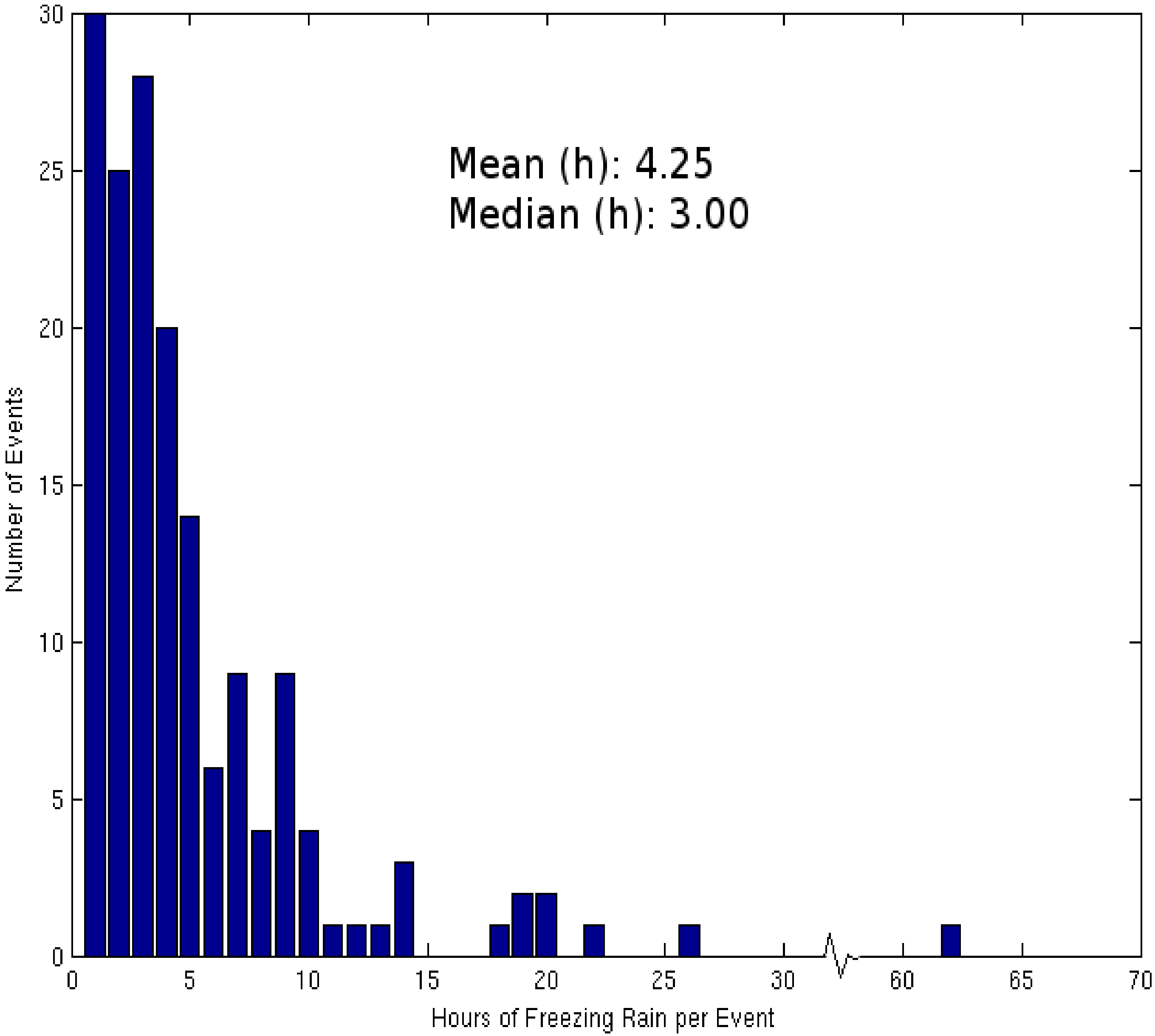
Montreal, December 2008

Data and Methodology

- Environment Canada hourly surface observations at Montreal, Quebec (CYUL) for the period 1979-2008
- National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR) dataset

Montreal, QC
December 2009

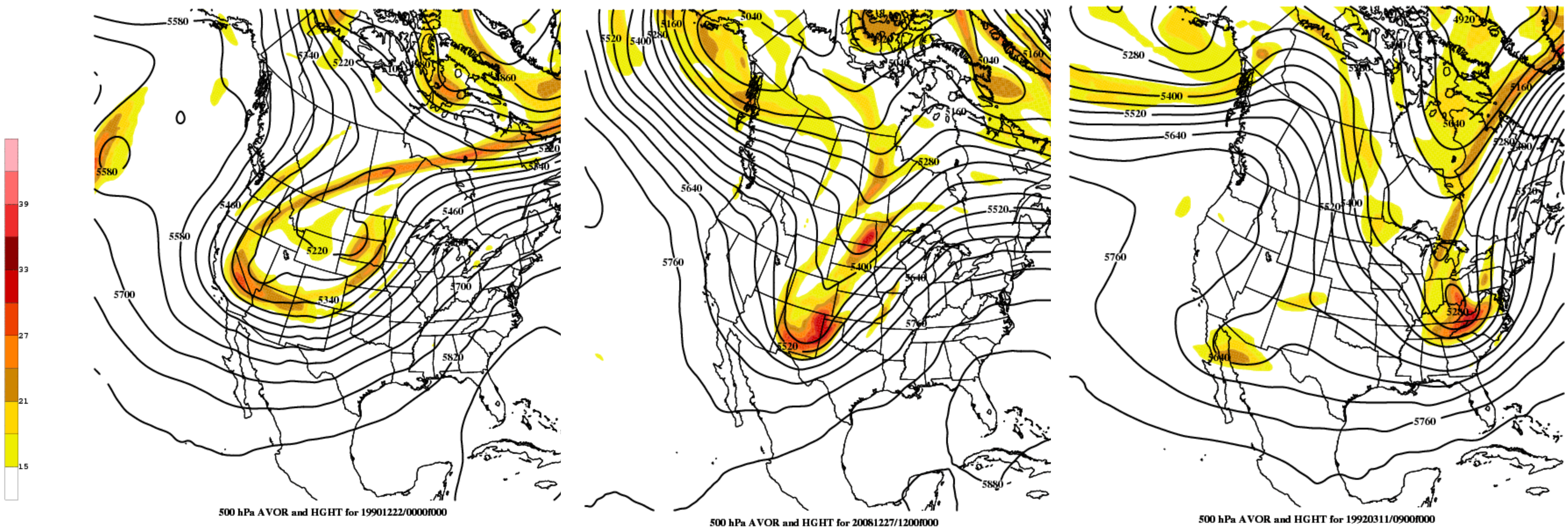
Data and Methodology



- 163 synoptically independent events
- Most are short-lived
- 98% “light” intensity
- Severe events ≡ 6 or more hours of freezing rain per event
- 46 severe events

Manual Synoptic Partitioning

- 46 severe events were partitioned according to the location and tilt of the long-wave 500-hPa trough axis

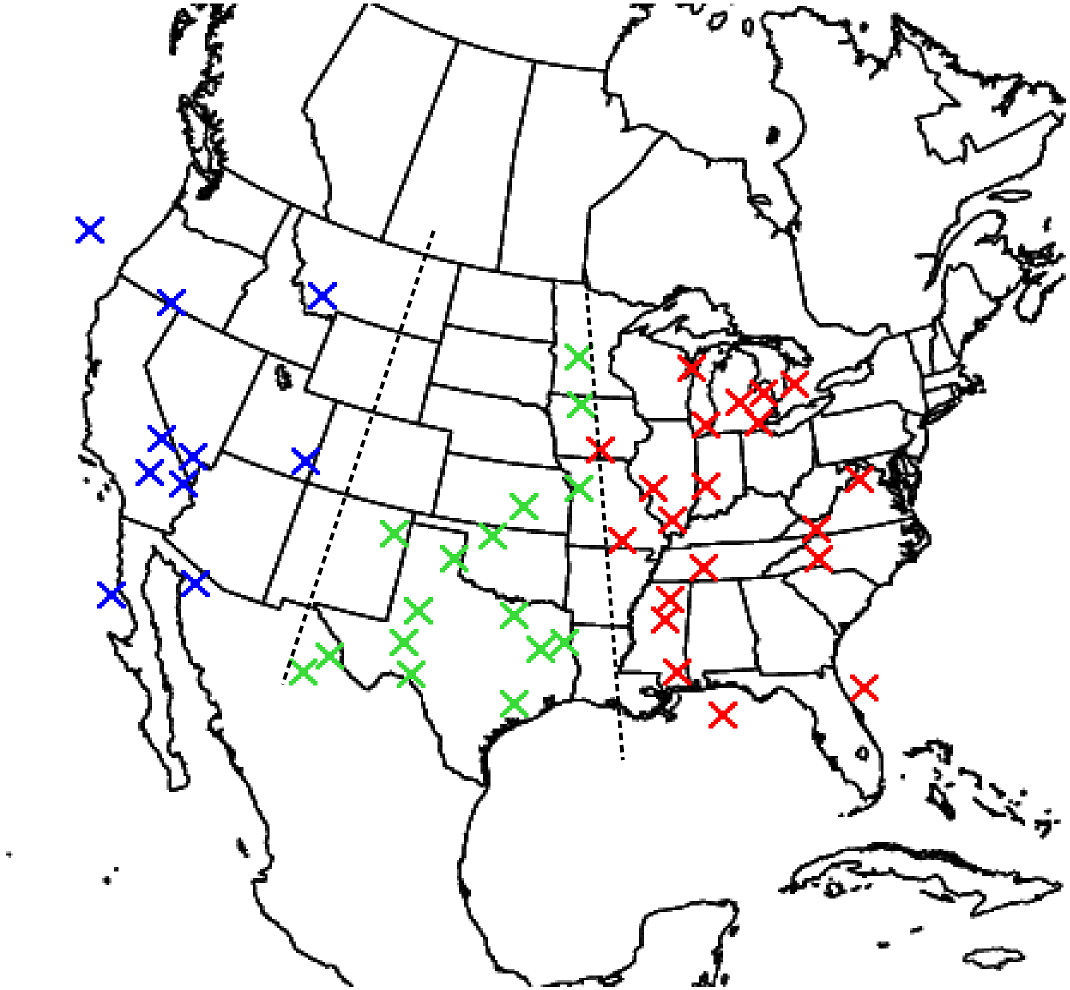


West **Central** **East**

500-hPa heights (m; contoured) and absolute vorticity (10^{-5} s^{-1}; shaded)

Manual Synoptic Partitioning

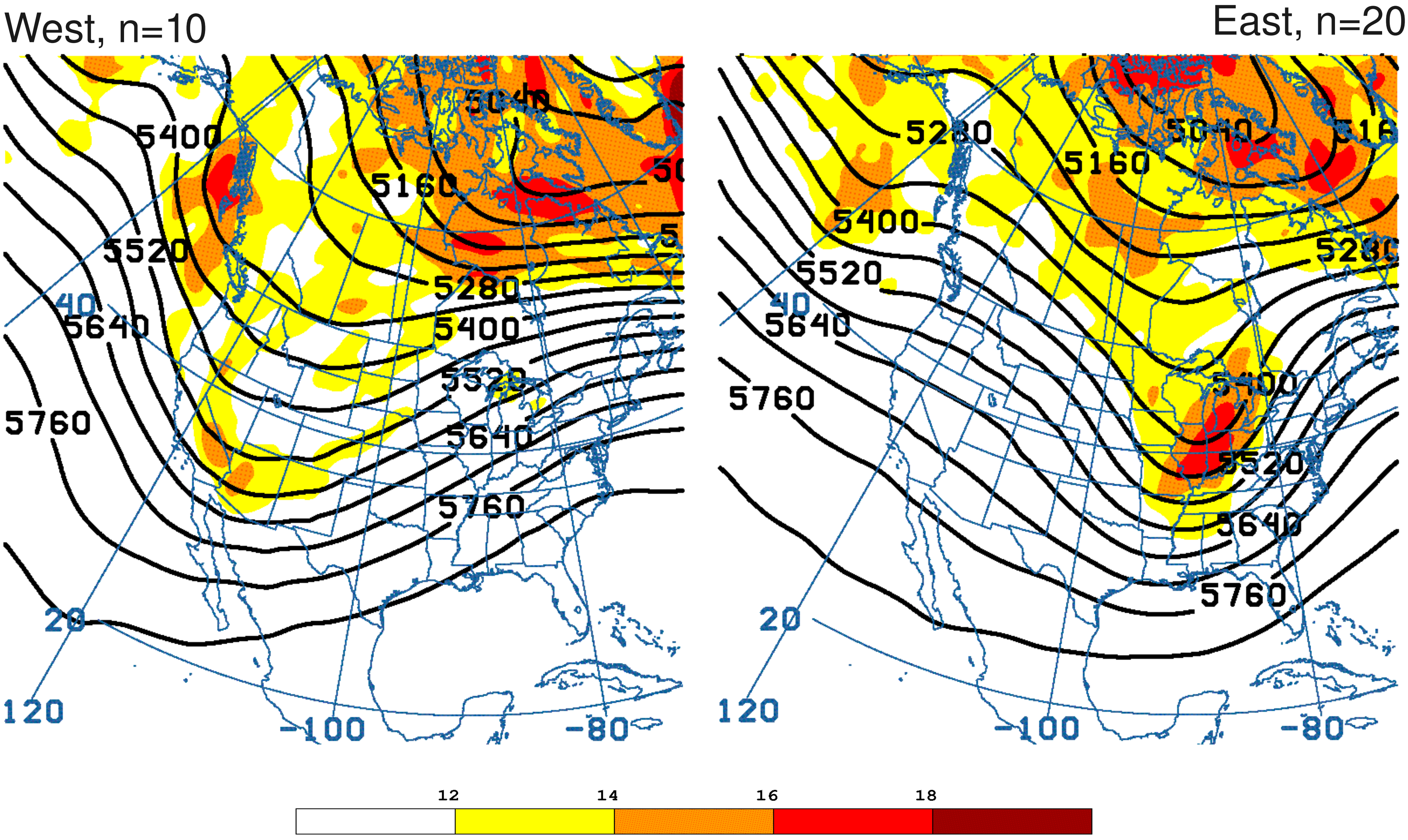
West, n=10
Central, n=16
East, n=20



Long-wave absolute vorticity maxima for west (blue), central (green), and east (red) synoptic types

500-hPa height (m; contoured), 500-hPa absolute vorticity (10^{-5} s^{-1}; shaded)

t = 0 h

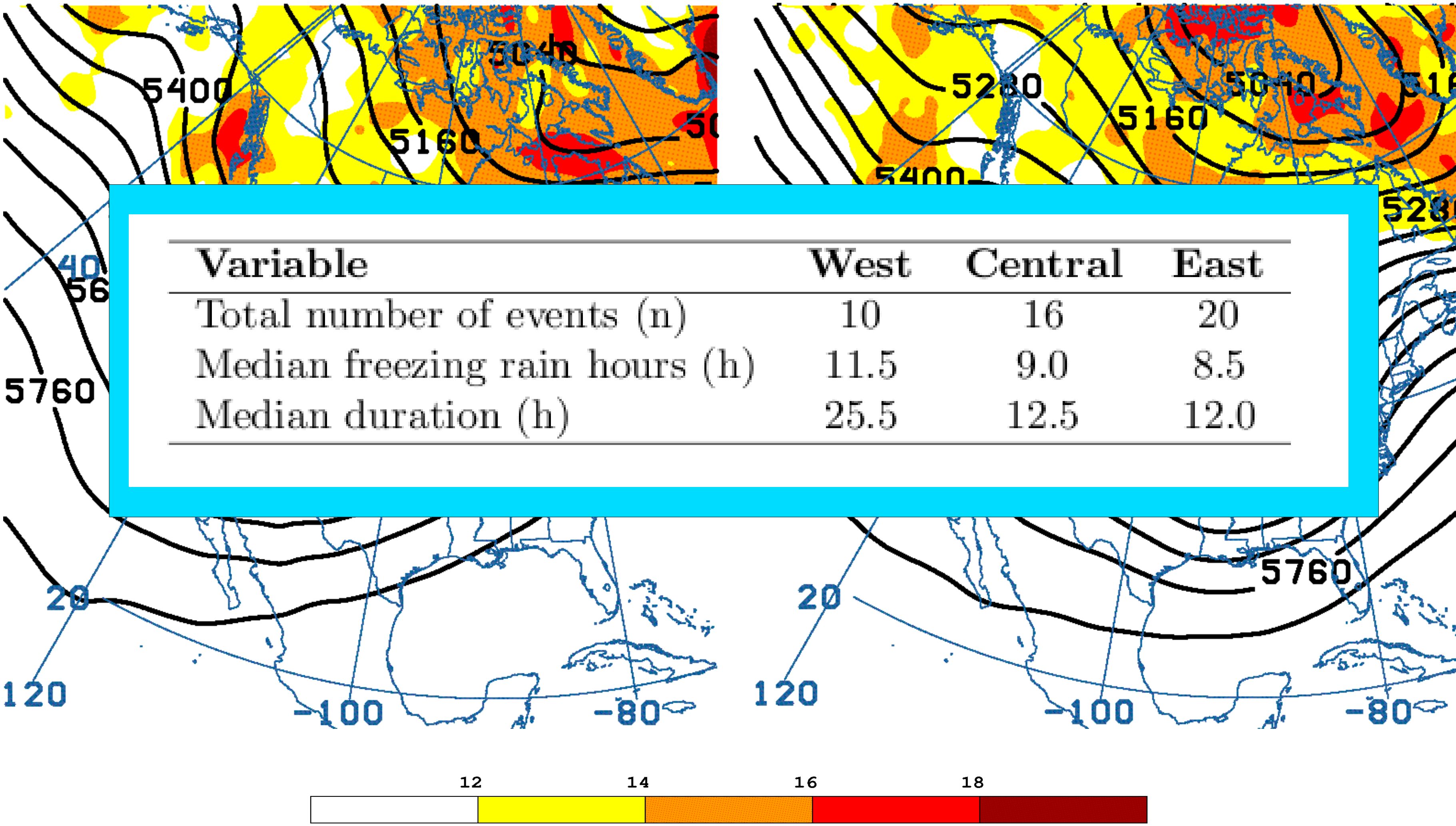


500-hPa height (m; contoured), 500-hPa absolute vorticity (10^{-5} s^{-1}; shaded)

t = 0 h

West, n=10

East, n=20



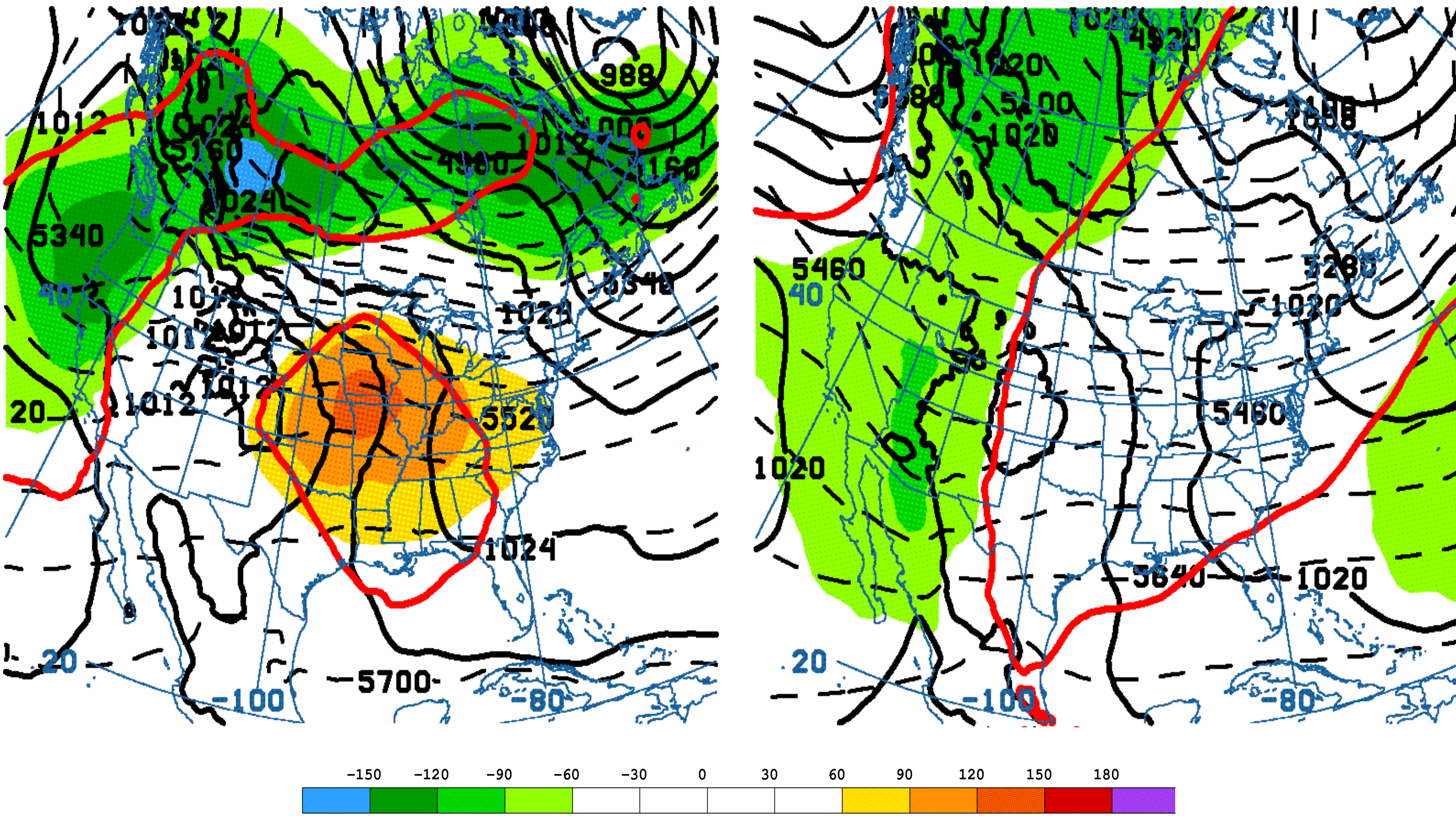
Variable	West	Central	East
Total number of events (n)	10	16	20
Median freezing rain hours (h)	11.5	9.0	8.5
Median duration (h)	25.5	12.5	12.0

MSLP (hPa; solid), 1000-500-hPa thickness (m; dashed), thickness anomalies (m; shaded), 99% confidence interval for anomalies (red dashed)

t = -48 h

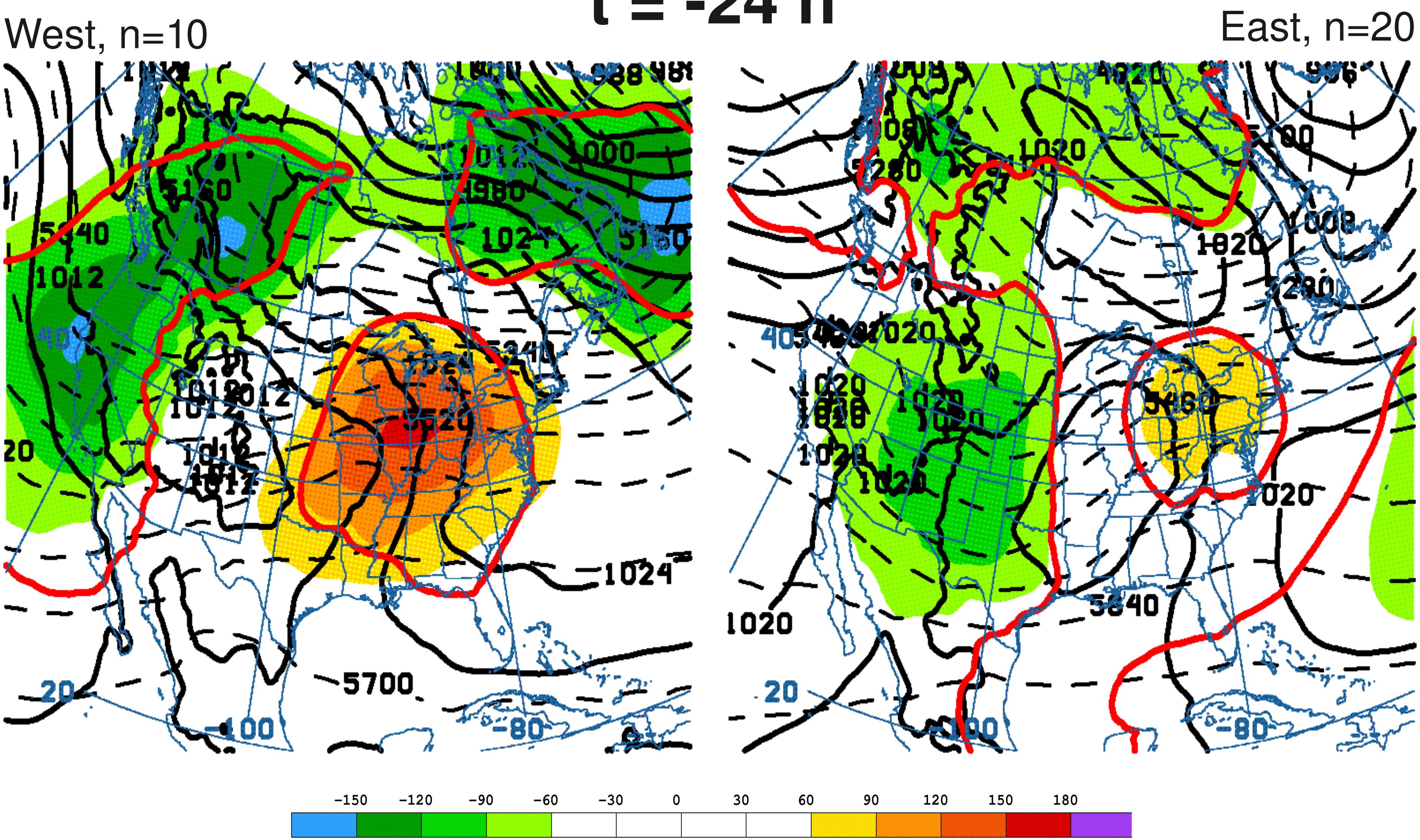
West, n=10

East, n=20



MSLP (hPa; solid), 1000-500-hPa thickness (m; dashed), thickness anomalies (m; shaded), 99% confidence interval for anomalies (red dashed)

t = -24 h



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t = 0 h

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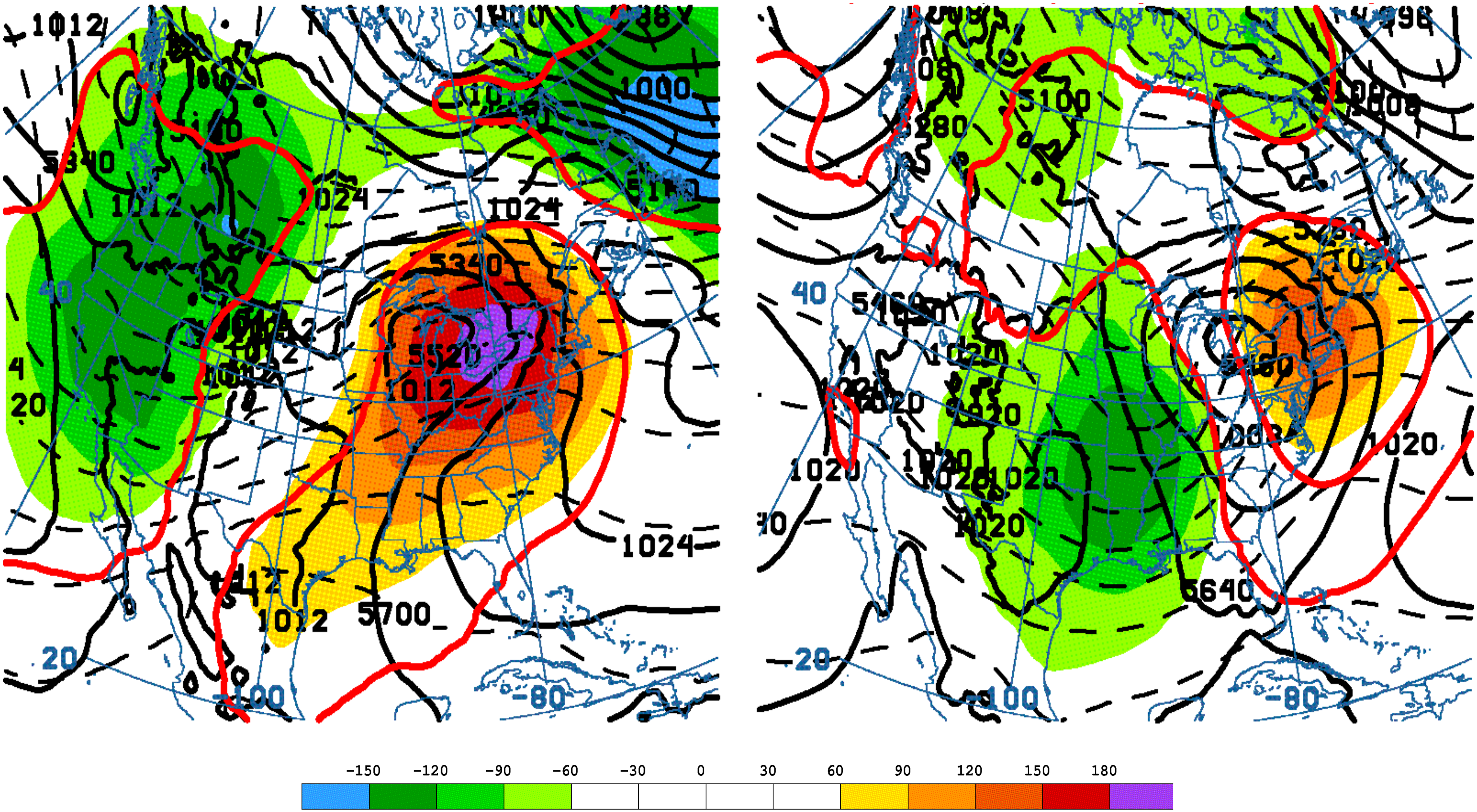
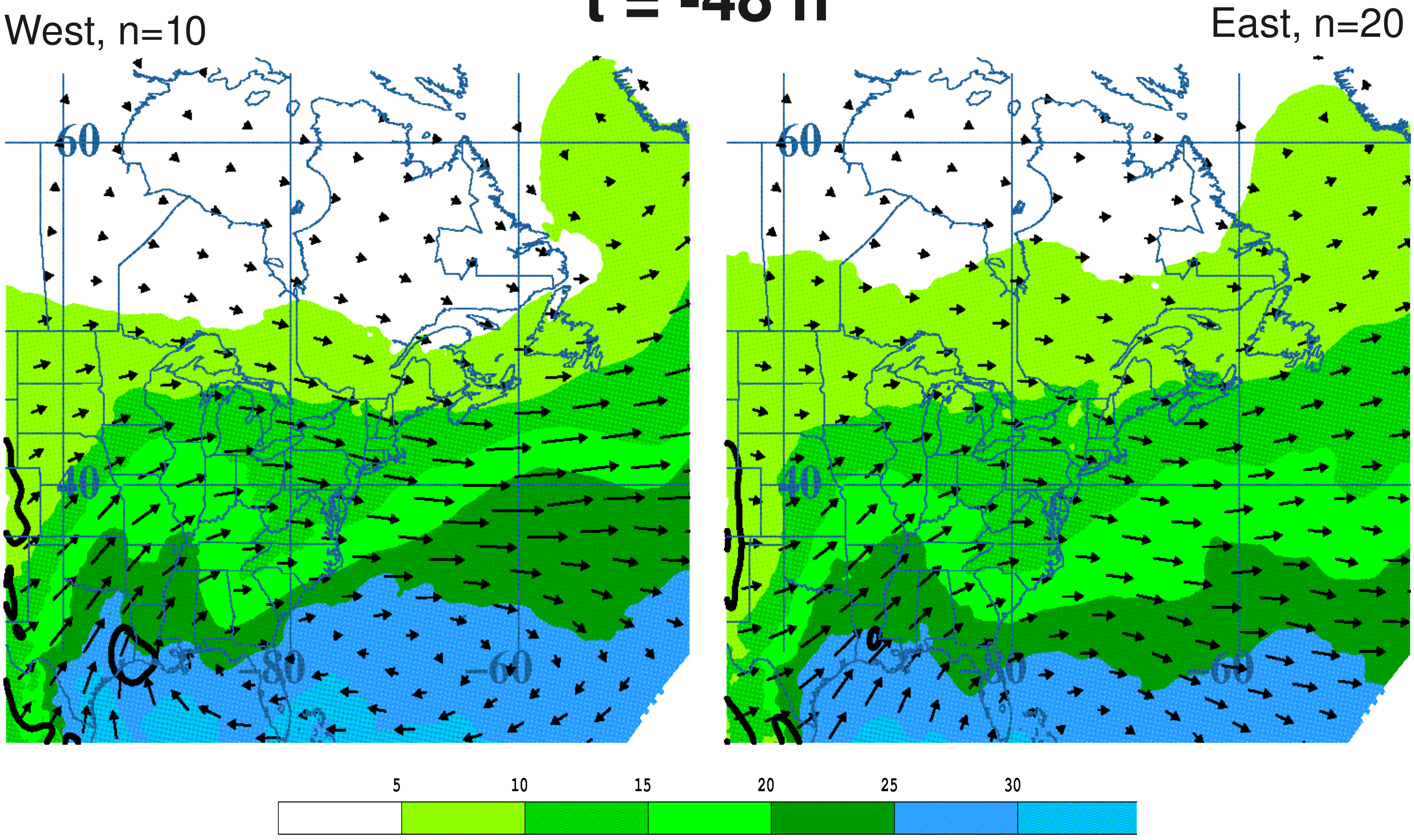
East, n=20



Precipitable water (mm; shaded), water vapour transport (kg m^{-1} s^{-1}; arrows), water vapour transport convergence (-2x10^{-7} kg m^{-1} s^{-1}; contoured)

t = -48 h



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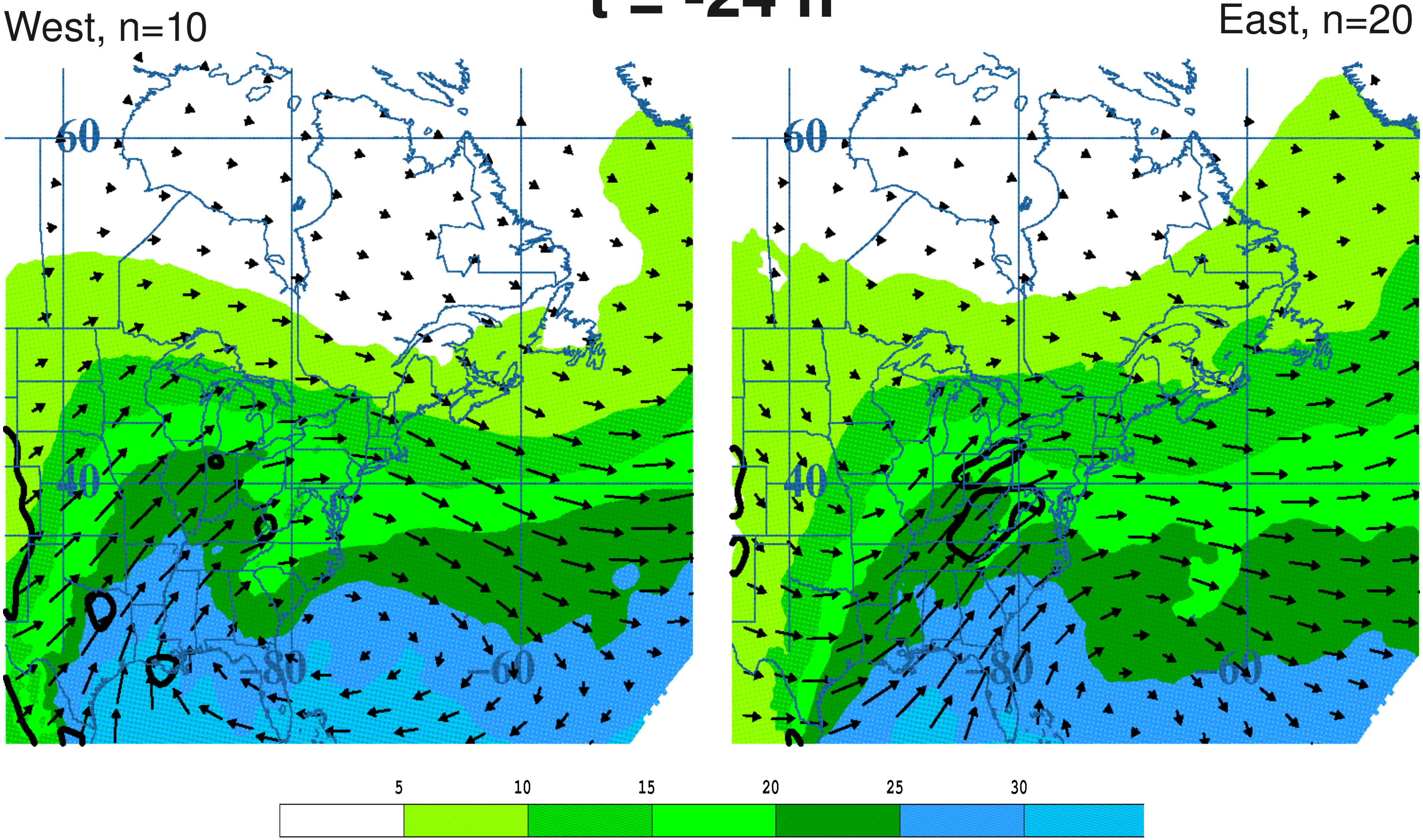

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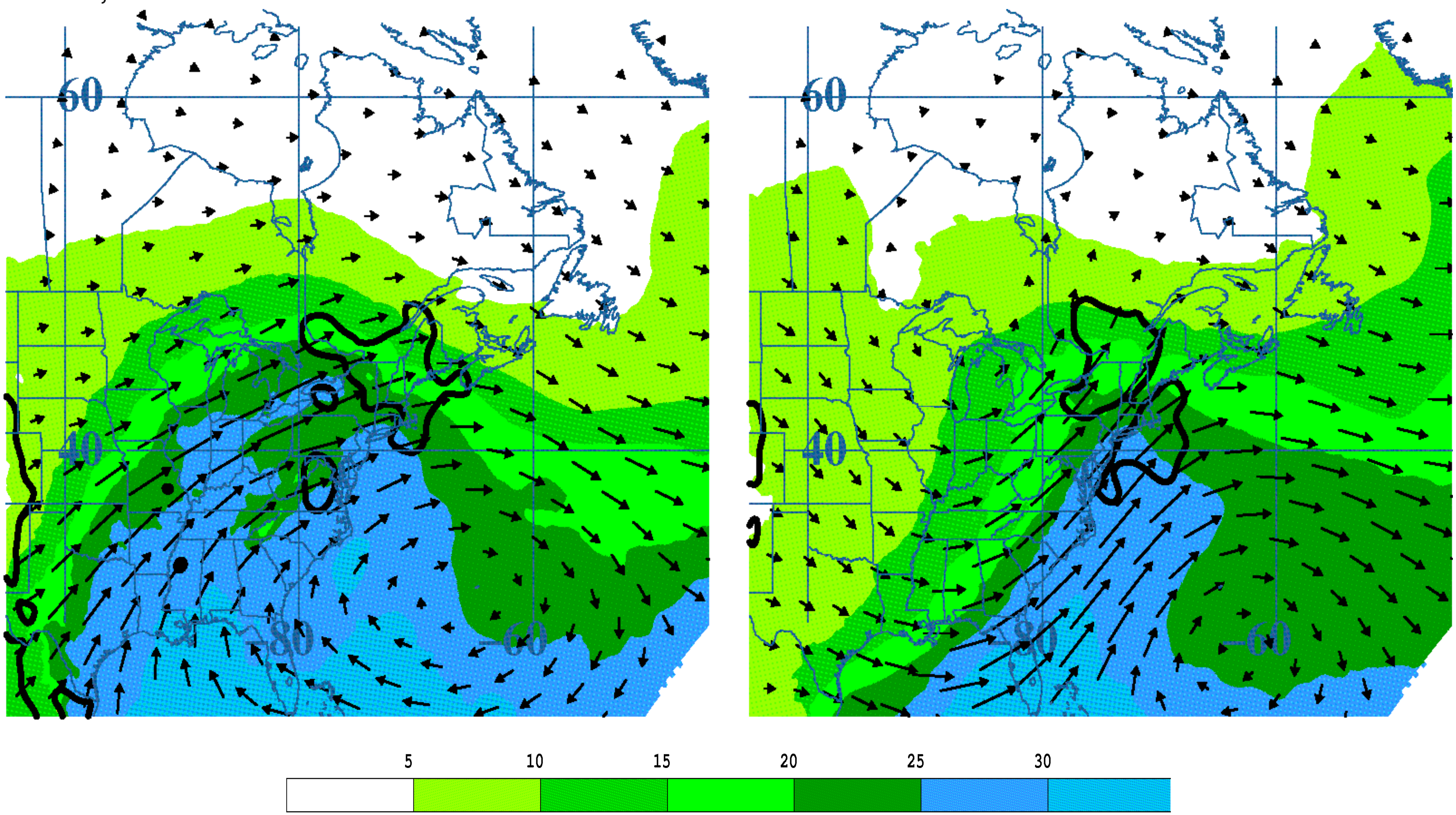
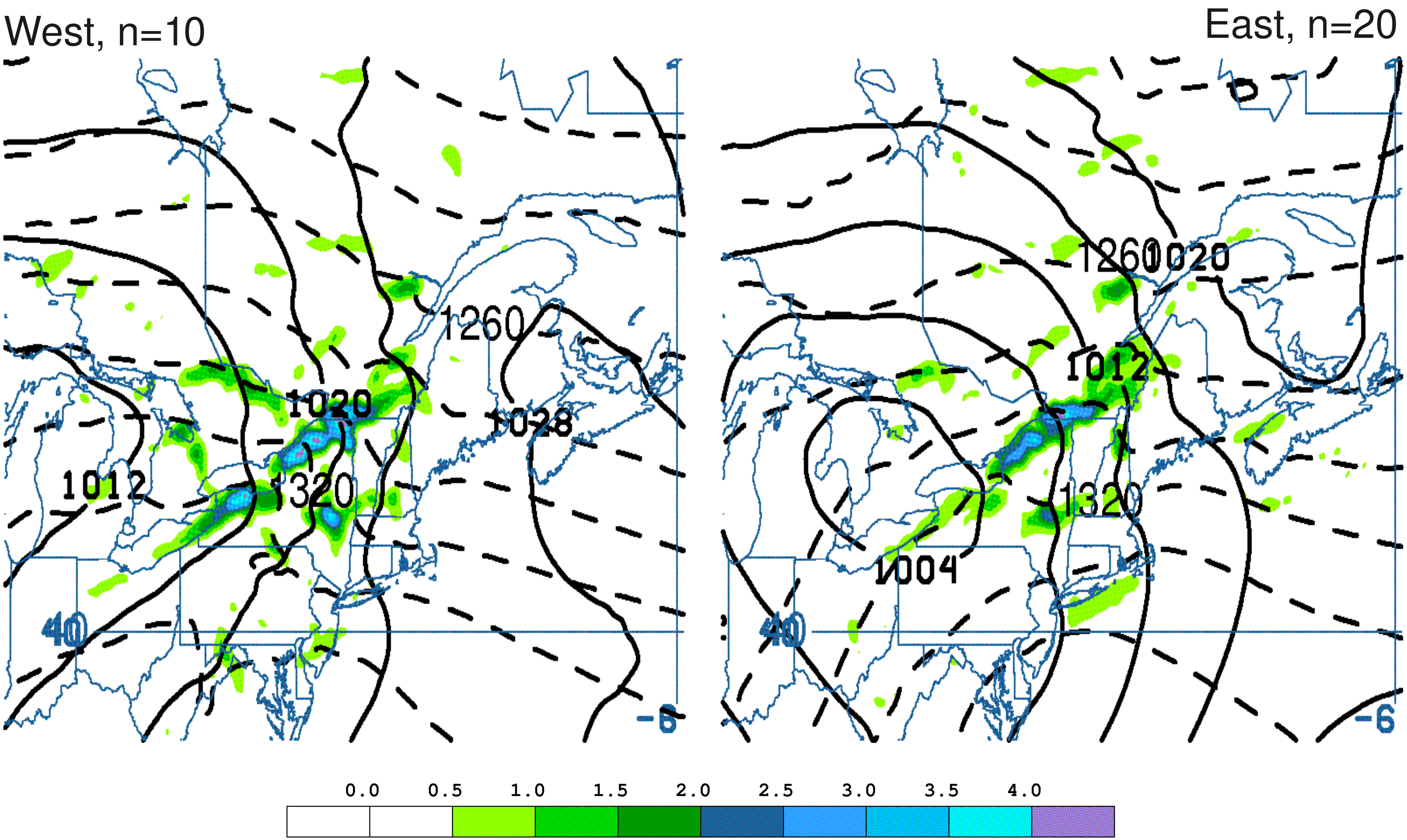
East, n=20



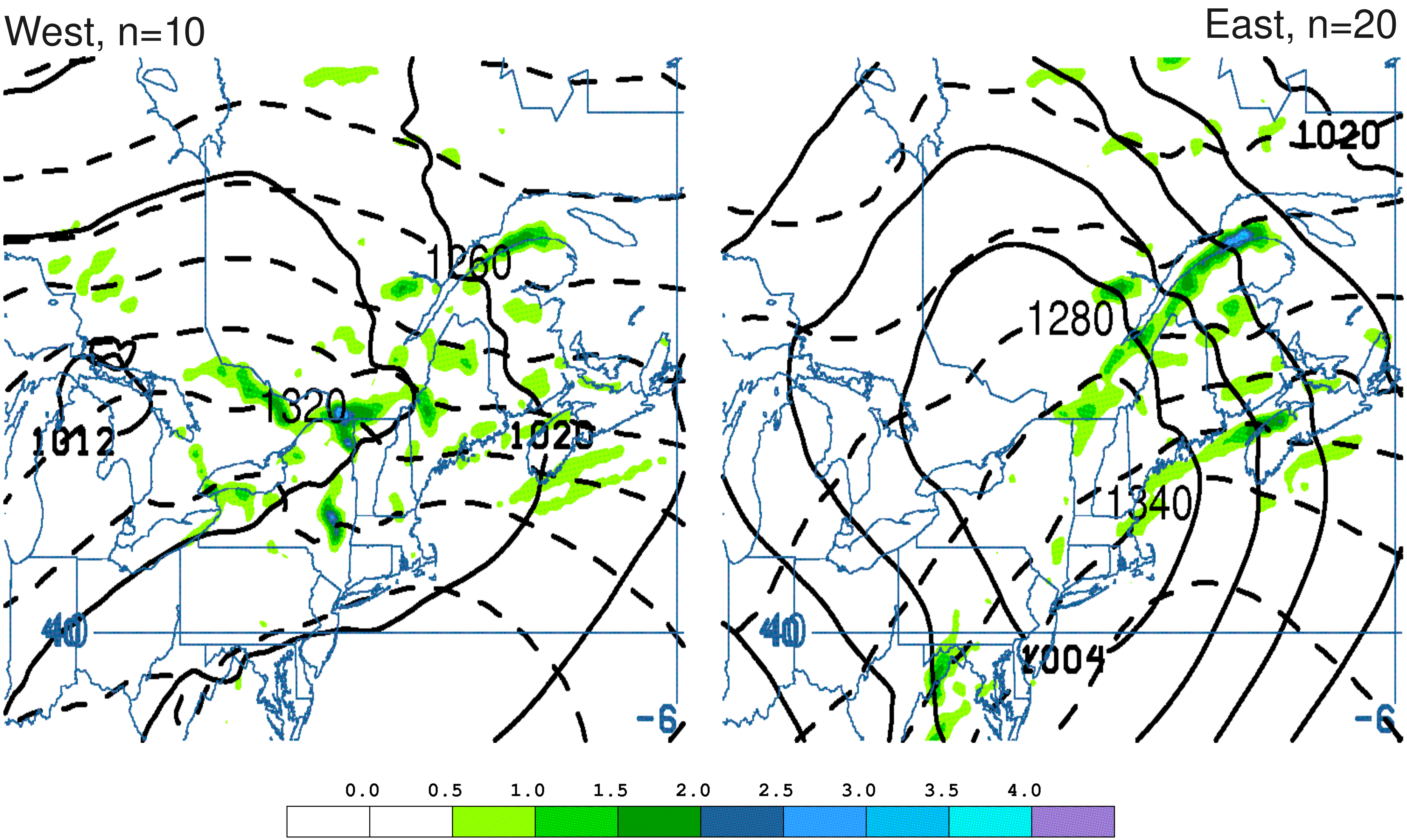
MSLP (hPa; solid), 1000-850-hPa thickness (m; dashed), 1000-850-hPa frontogenesis (K $(100km)^{-1}(3h)^{-1}$; shaded)

t = 0 h



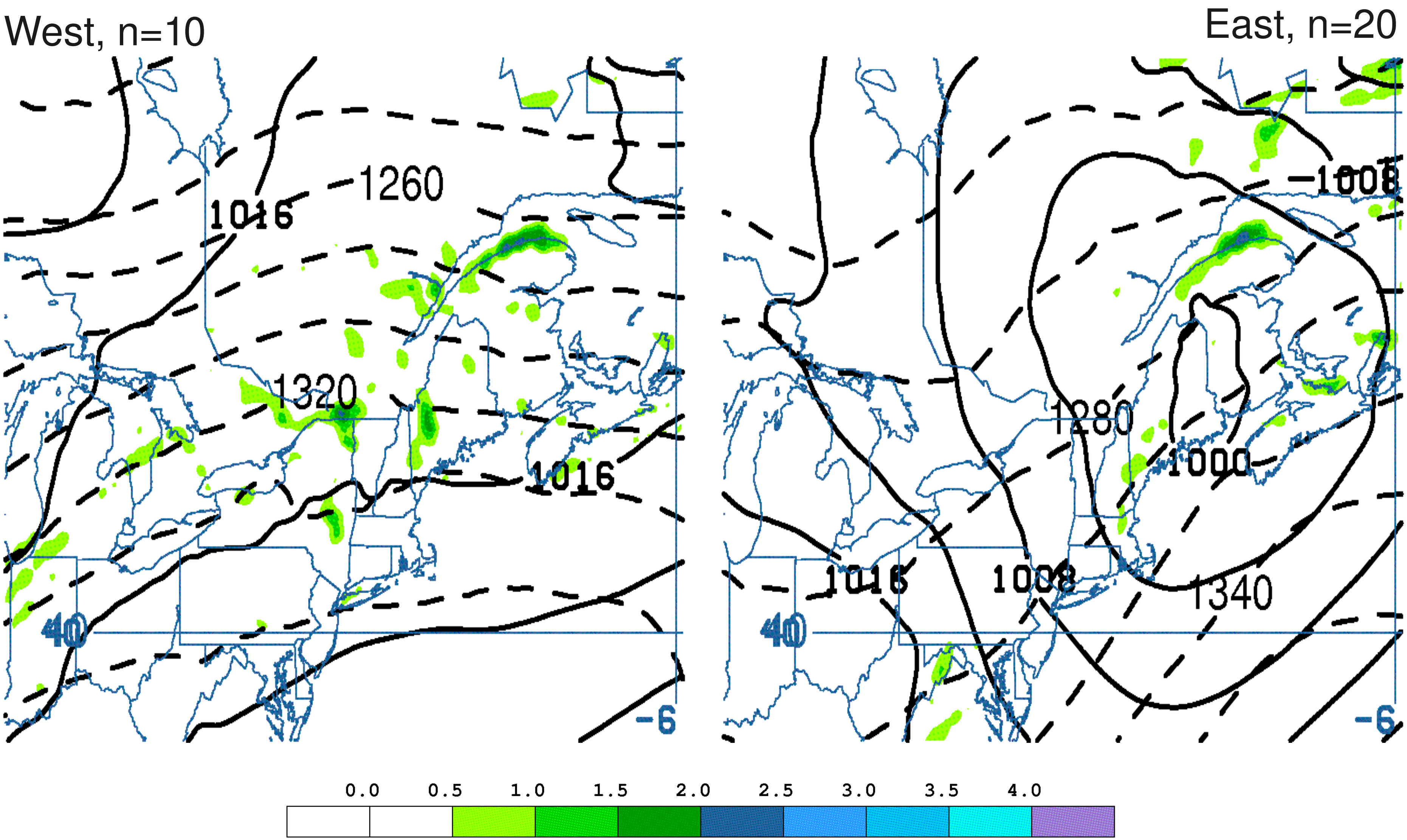
MSLP (hPa; solid), 1000-850-hPa thickness (m; dashed), 1000-850-hPa frontogenesis (K (100km)$^{-1}$(3h)$^{-1}$; shaded)

t = +12 h



MSLP (hPa; solid), 1000-850-hPa thickness (m; dashed), 1000-850-hPa frontogenesis (K $(100km)^{-1}(3h)^{-1}$; shaded)

t = +24 h

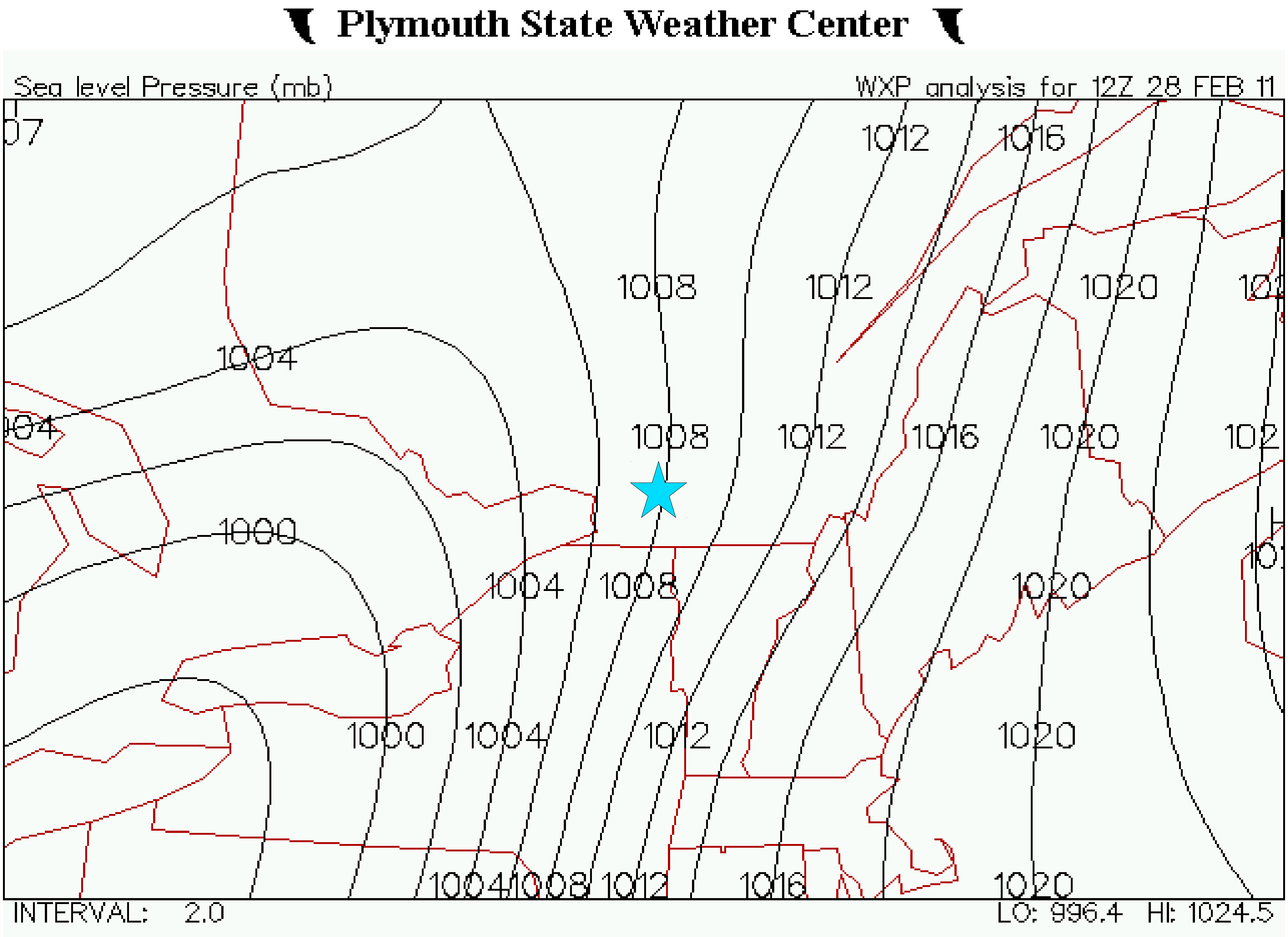


Composite Analysis Conclusions

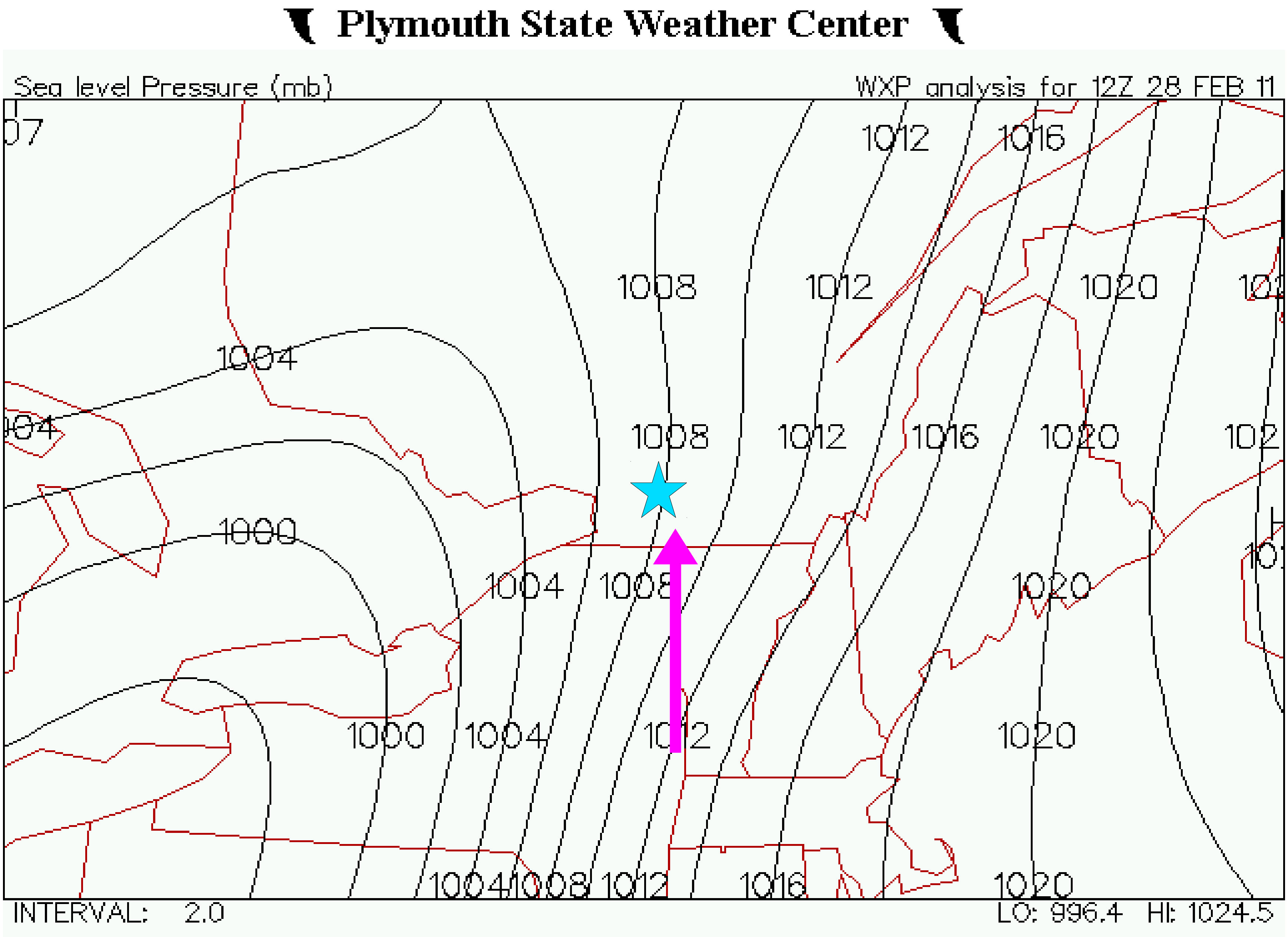
- WEST composite
  - Long upper-level wavelength: slower eastward movement
  - Southwesterly geostrophic flow: moisture from the Gulf of Mexico
  - Valley-enhanced frontogenesis
- EAST composite
  - Short upper-level wavelength: faster eastward movement
  - Southeasterly geostrophic flow: moisture from the East Coast
  - Passage of a midlatitude cyclone

For sustained freezing rain, there must be a ***pressure gradient force*** *aligned with the St. Lawrence River Valley – whether it results from a cyclone, anticyclone, or couplet.*

Just one caveat...



Southerly channeling!



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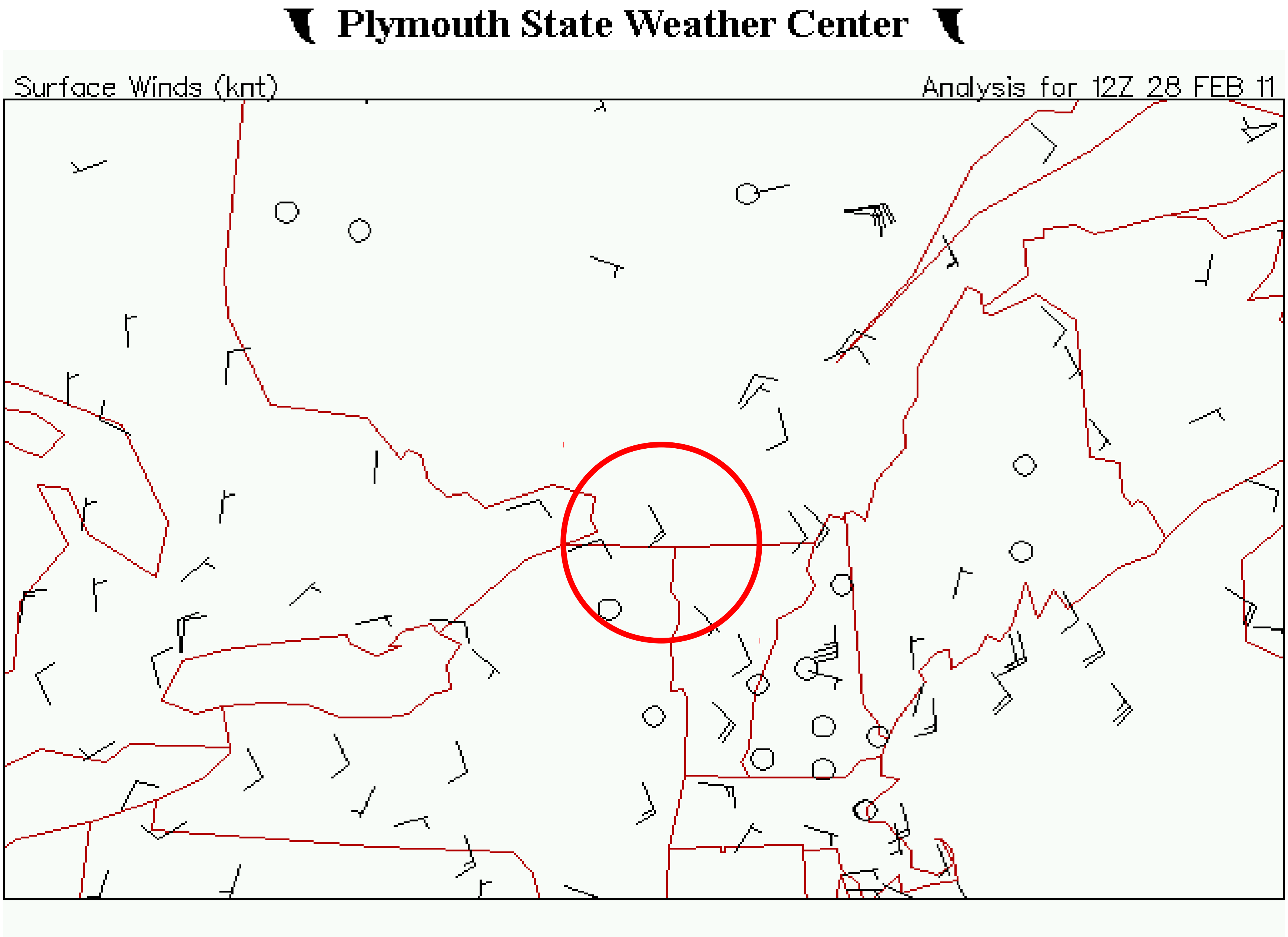

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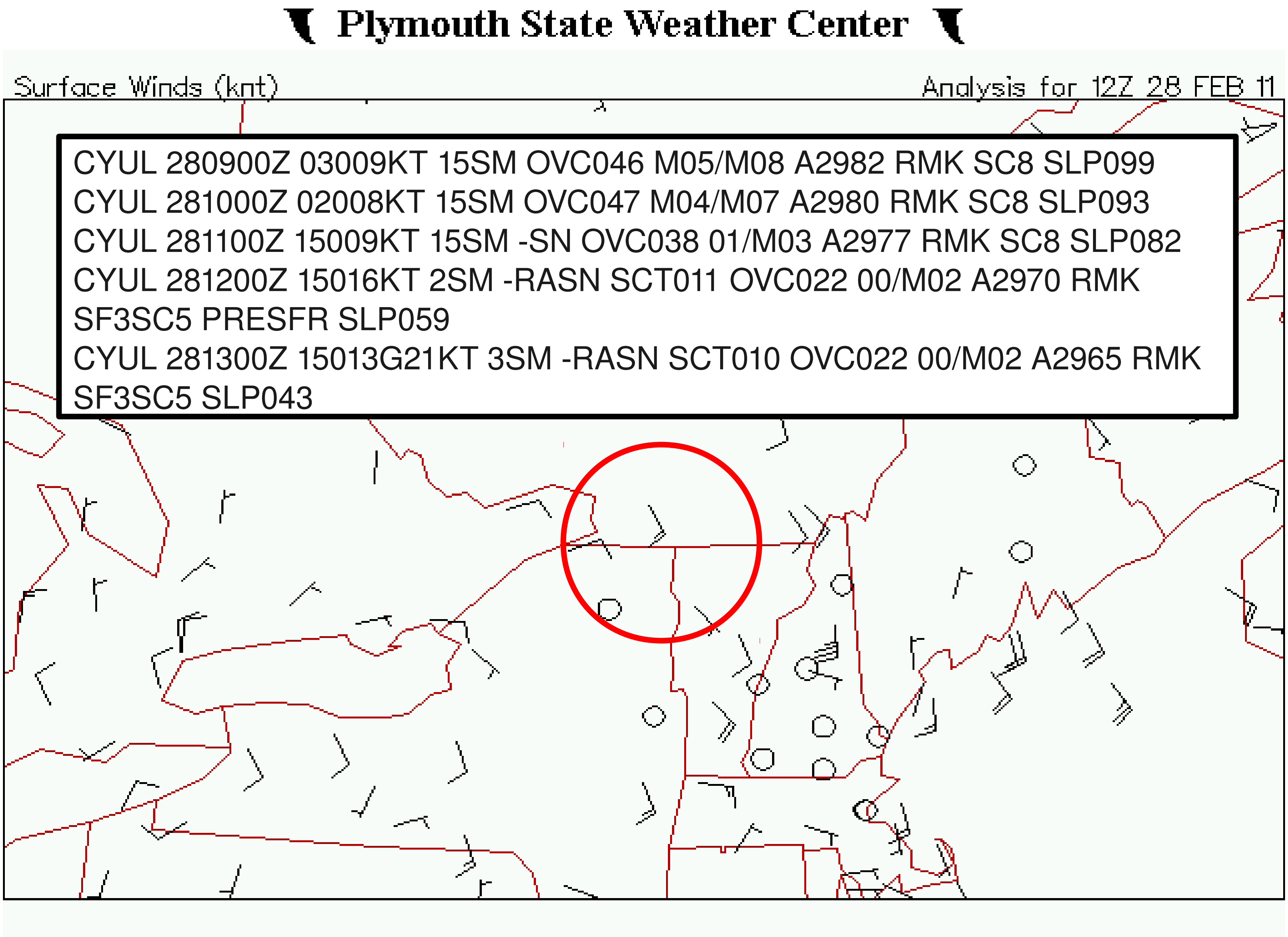

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CYUL 281200Z 15016KT 2SM -RASN SCT011 OVC022 00/M02 A2970 RMK SF3SC5 PRESFR SLP059
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