

MET 4300

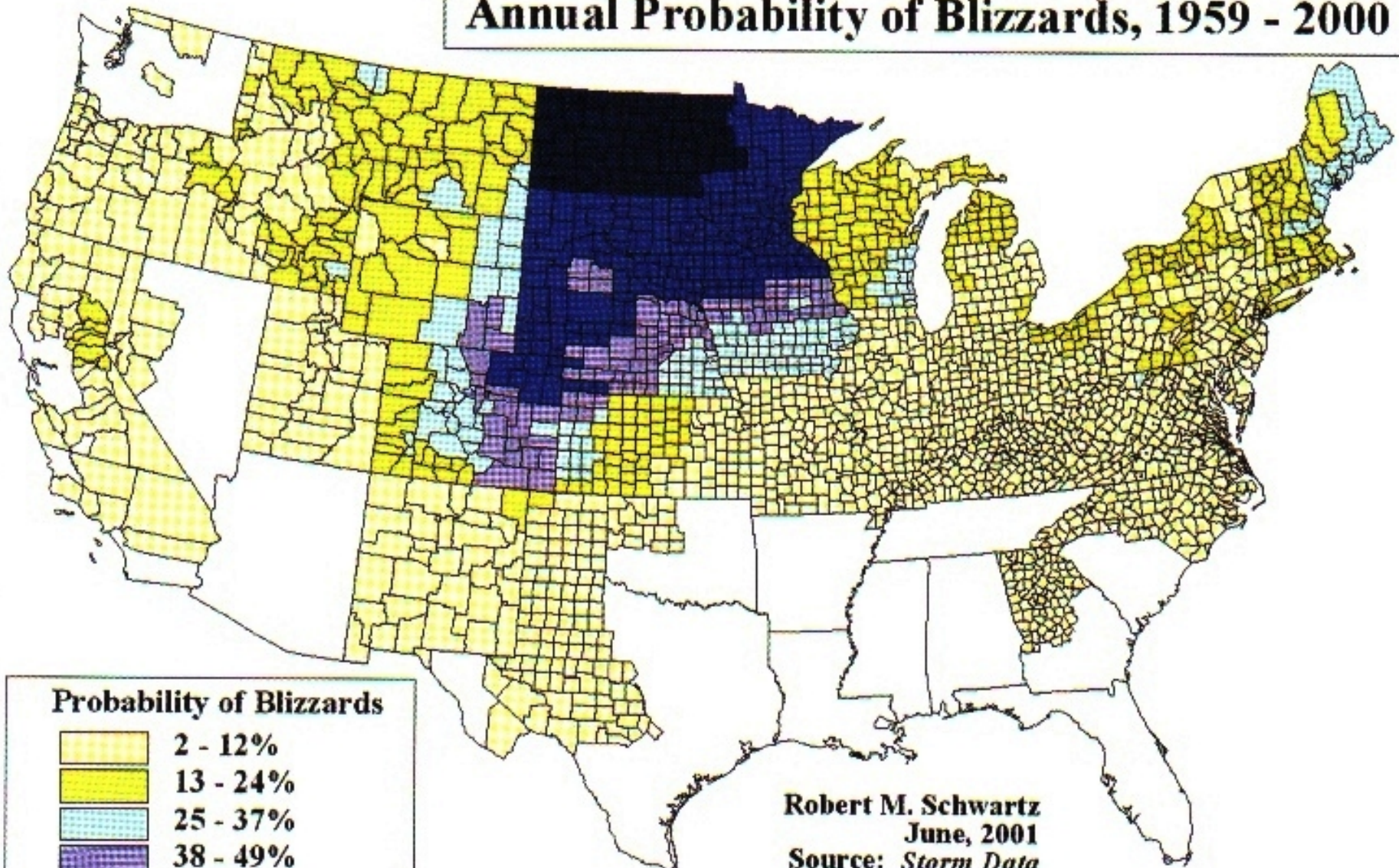
Lecture 15 **Blizzards(CH15)**

Blizzards

- Winds > 30 kt (35 mph)
- Visibility < ¼ mi in blowing or falling snow
- Last > 3h
- Can cause **hypothermia** and **frostbite**; economic loss can reach millions
- Mainly happen in the Great Plains of the northern US and southern Canada due to the unique geography: N-S mountain massif isolates the lower troposphere on the Great Plains from the warm air over the Pacific.
- Cold air mass over Canadian Arctic due to long Arctic winter nights; Lee cyclones drive blizzards; Moisture is provided by the Gulf of Mexico.



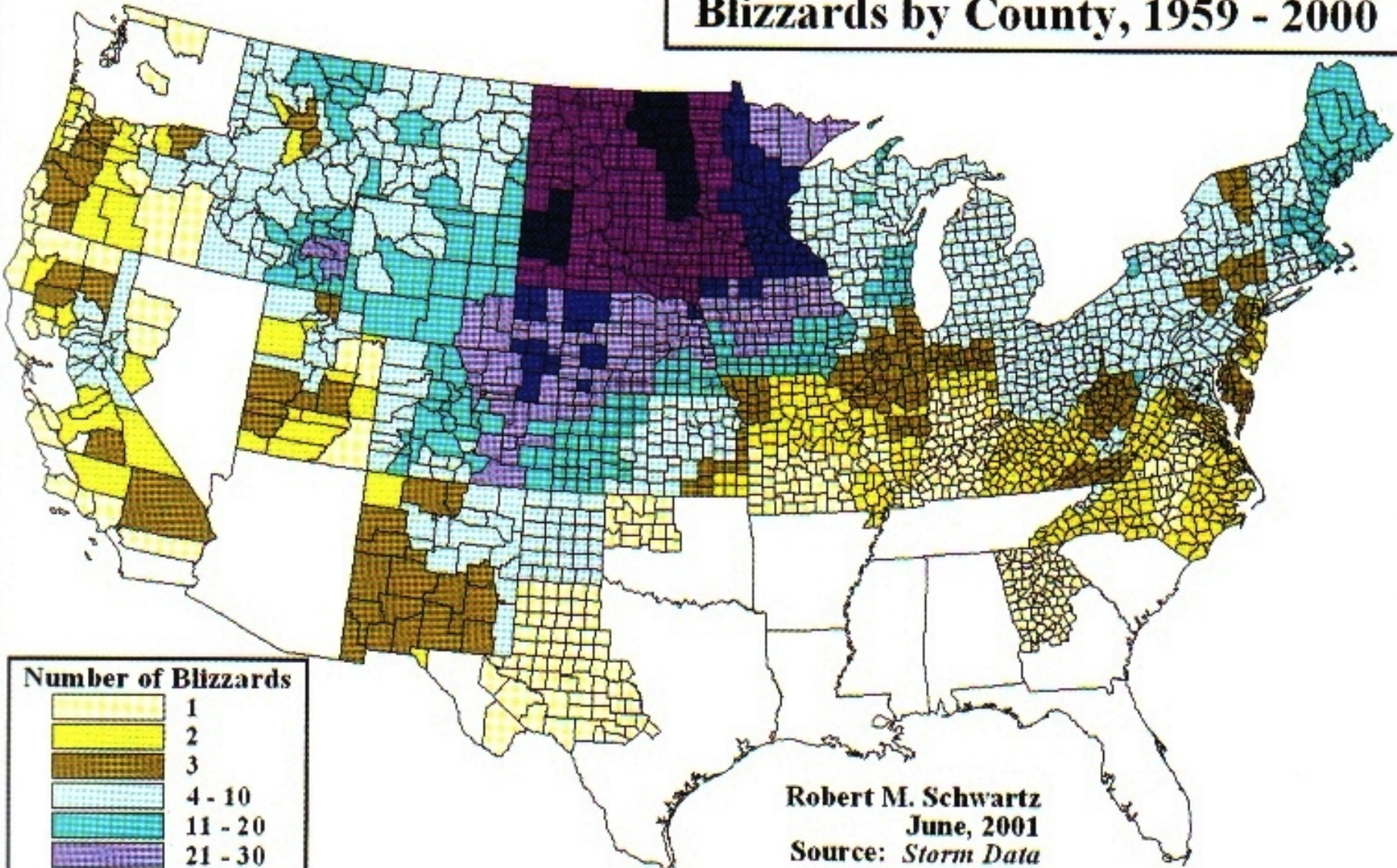
Annual Probability of Blizzards, 1959 - 2000



Robert M. Schwartz
June, 2001
Source: *Storm Data*

High probability (>50%) over North & South Dakota, Minnesota, Nebraska, northern Iowa, and eastern Colorado

Blizzards by County, 1959 - 2000



Number of Blizzards	
Light yellow	1
Yellow	2
Brown	3
Light blue	4 - 10
Teal	11 - 20
Purple	21 - 30
Dark blue	31 - 40
Dark purple	41 - 60
Black	61 - 74

Robert M. Schwartz
June, 2001
Source: Storm Data

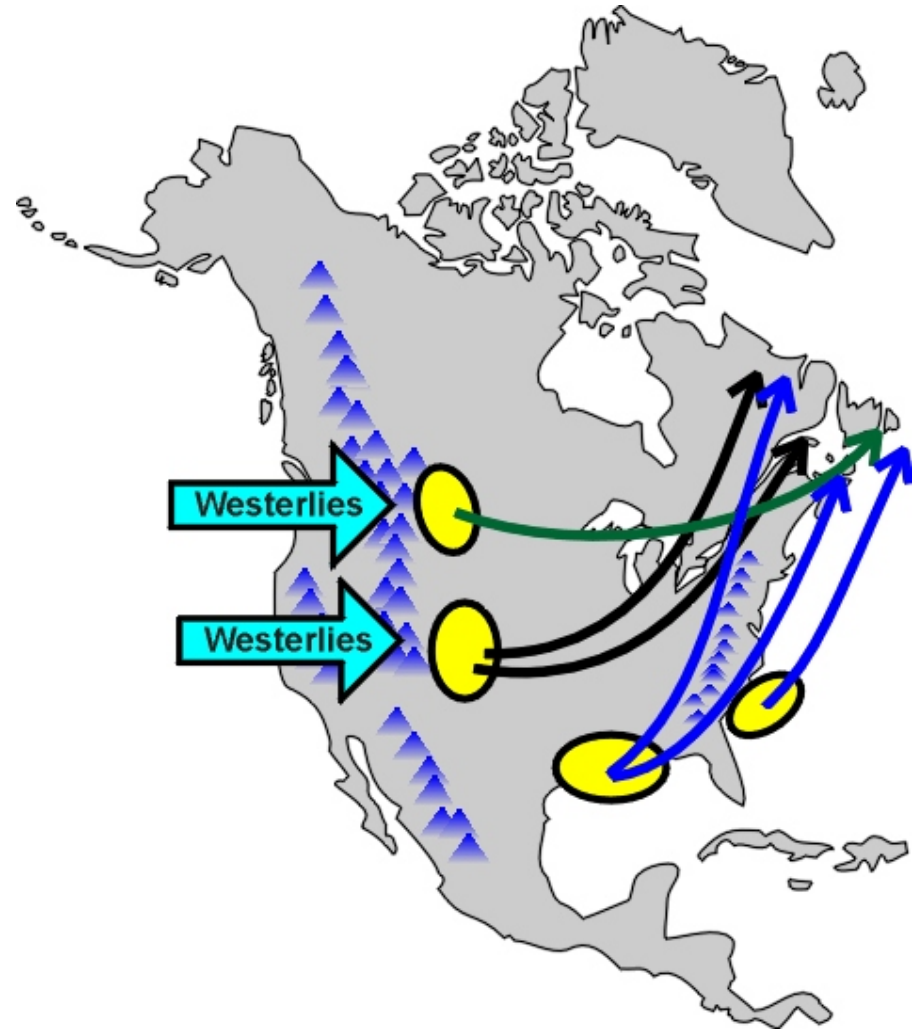
Average about 1-2 blizzards
Per year over ND, SD, and MN

Three Ingredients necessary for a blizzard to form

- ***Extremely cold air***: originates on the plains of west-central Canada in winter, snow-covered surface, infrared radiative cooling, solar reflection, long winter nights, under clear skies → strong high pressure system (increase the pressure gradient)
- Blizzards occur within Lee cyclones, which provide ***wind*** and ***snow***. The worst blizzards typically occur with Colorado cyclones, but blizzards associated with Alberta Clippers normally have the coldest temperatures.

Where Do US Frontal Cyclones Form?

- **Lee of the Rocky Mountains**
 - Alberta Clippers
 - Colorado Cyclones
- **Gulf Coast**
 - TX-LA boarder
 - Off Georgia-Carolinas Coast
- **East Cost**
- **Bering Sea & Gulf of Alaska in the Pacific Ocean (Pacific Cyclones)**

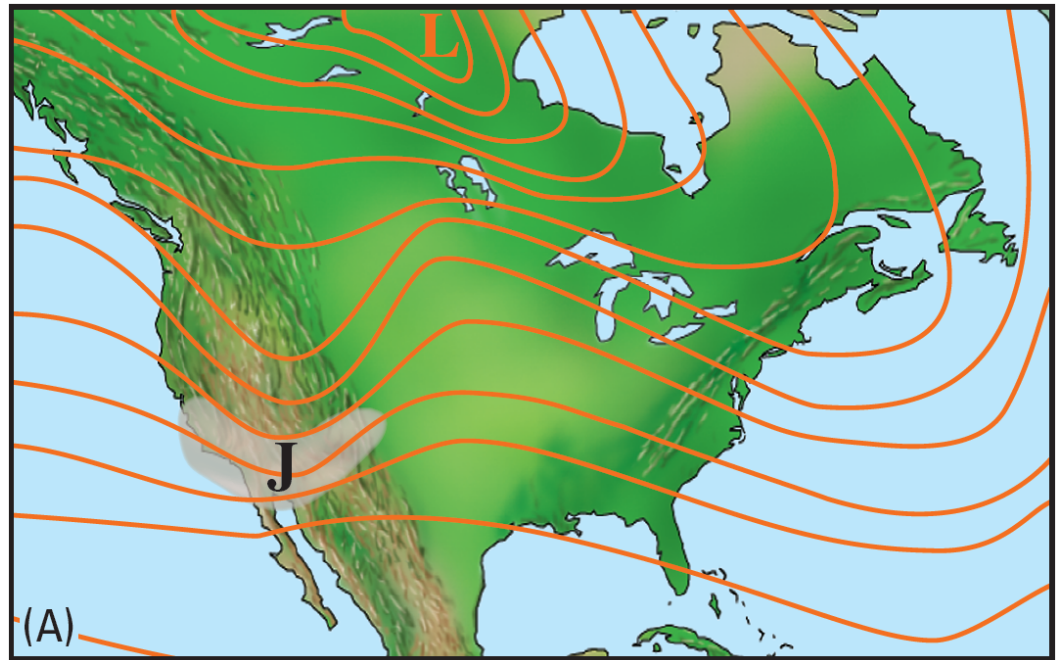


Three Types of Blizzard in the US

- **Colorado Cyclone Blizzard**
- **Alberta Clipper Blizzard**
- **Ground Blizzard**

Colorado Cyclones and Blizzards: Development Stage

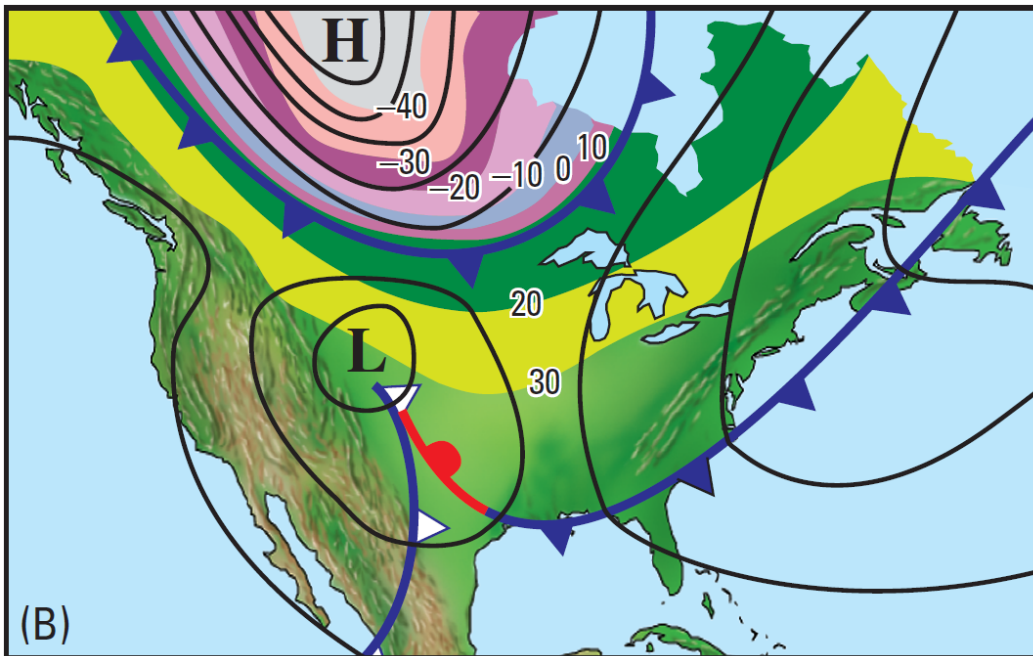
- A wave in the polar jetstream moves across the Colorado/New Mexico Rockies
- Curvature and jetstreak effects trigger the formation of surface low pressure.



Upper level (300mb)

Colorado Cyclones and Blizzards: Development Stage

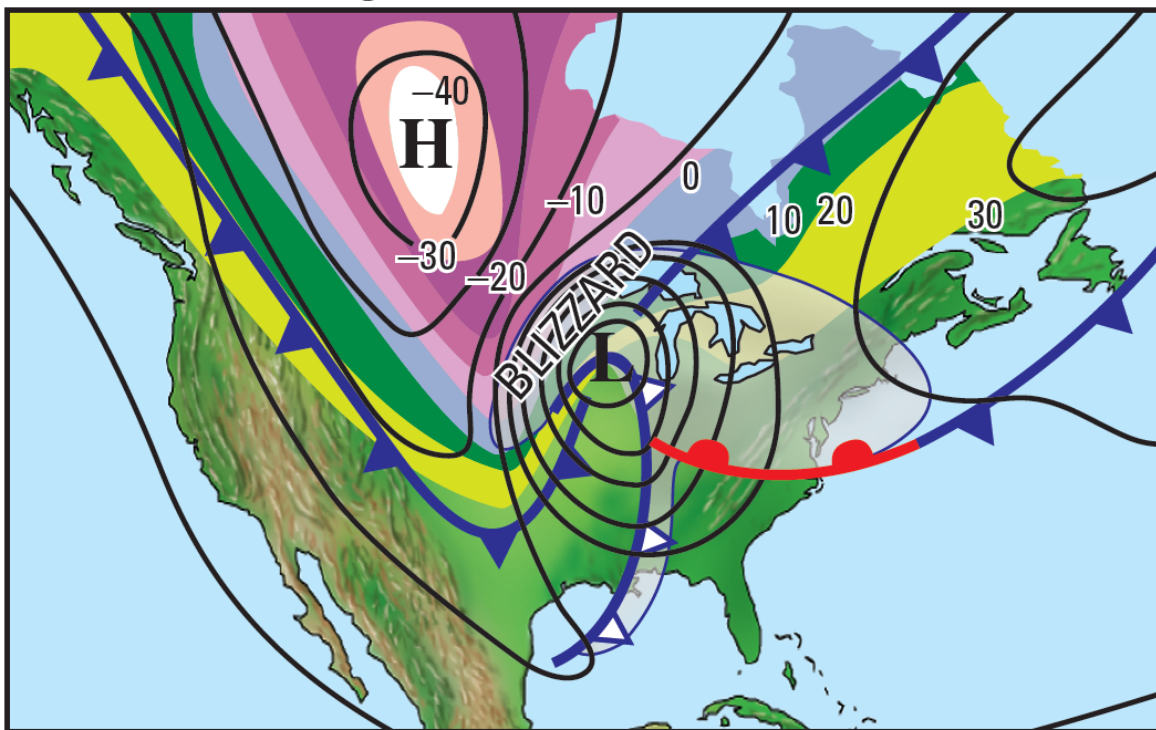
- **At surface**, for blizzard conditions to develop, bitter cold air and associated high pressure must already be in place over the Canadian Plains → behind the arctic front
- A surface cyclone develops eastern Colorado
- Midwinter cool temperatures are already in the US, due to previous cold air intrusion (southernmost cold front below).



Surface

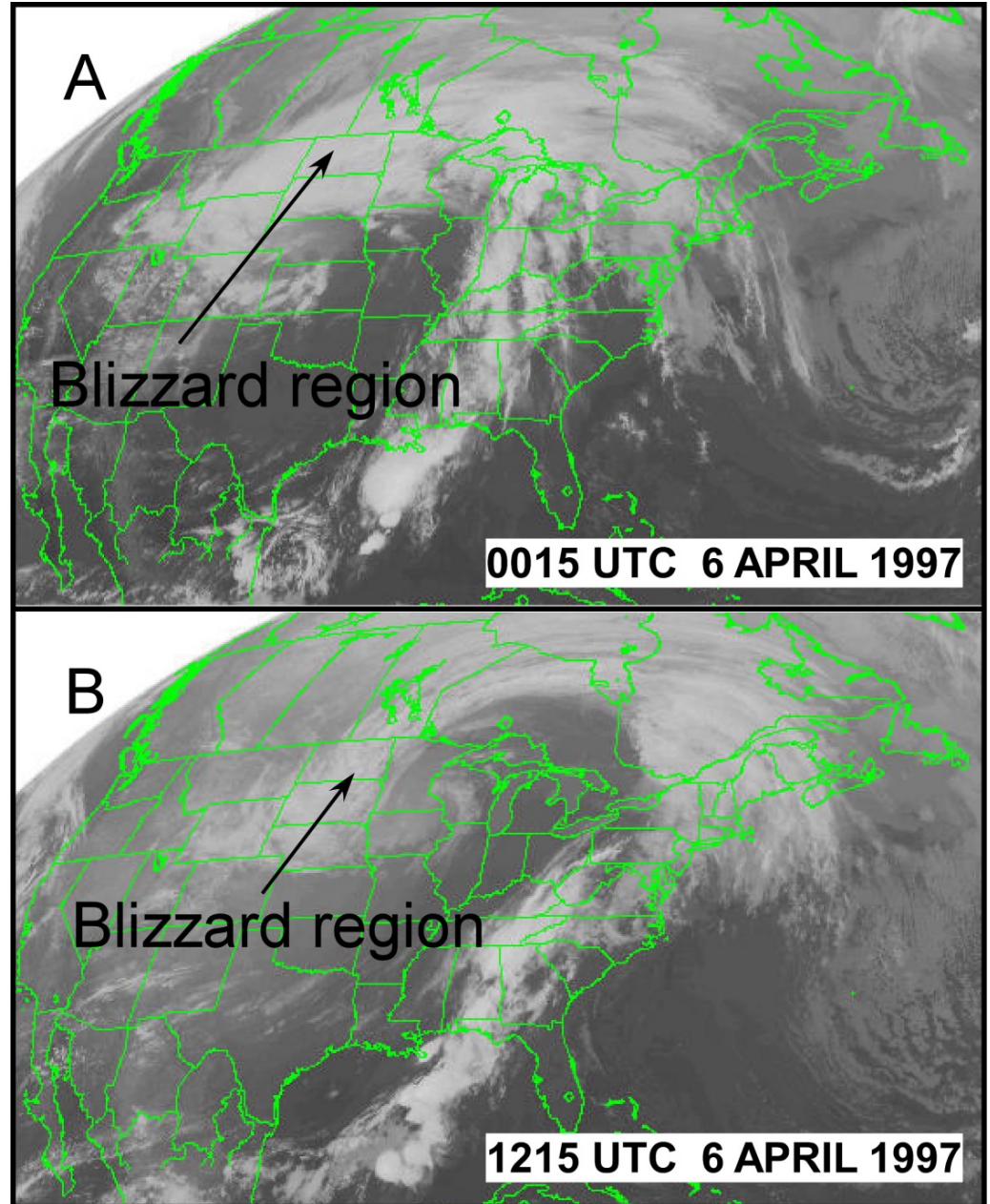
Mature Phase

- The arctic airmass moves southward as the cyclone moves eastward.
- The arctic front approaches the cyclone center, wraps around the west side of the cyclone.
- As the cyclone progress northeastward and intensifies, the strong pressure gradient drives the bitterly cold air southward west of the cyclone center, creating blizzard conditions



1997 North Dakota Blizzard

- At mature stage, warm air rising east of the upper-level front and over the warm front becomes wrapped aloft around the NW side of the low-pressure center, producing a band of clouds and precipitation → **Trowal** (a trough of warm air aloft)
- As the band narrows, air continuously rises, producing snow that falls into the arctic air below
- TROWAL provides moisture to feed the snowfall
- 1997 blizzard buried ND: the clouds deform and narrow in 12-hrs.

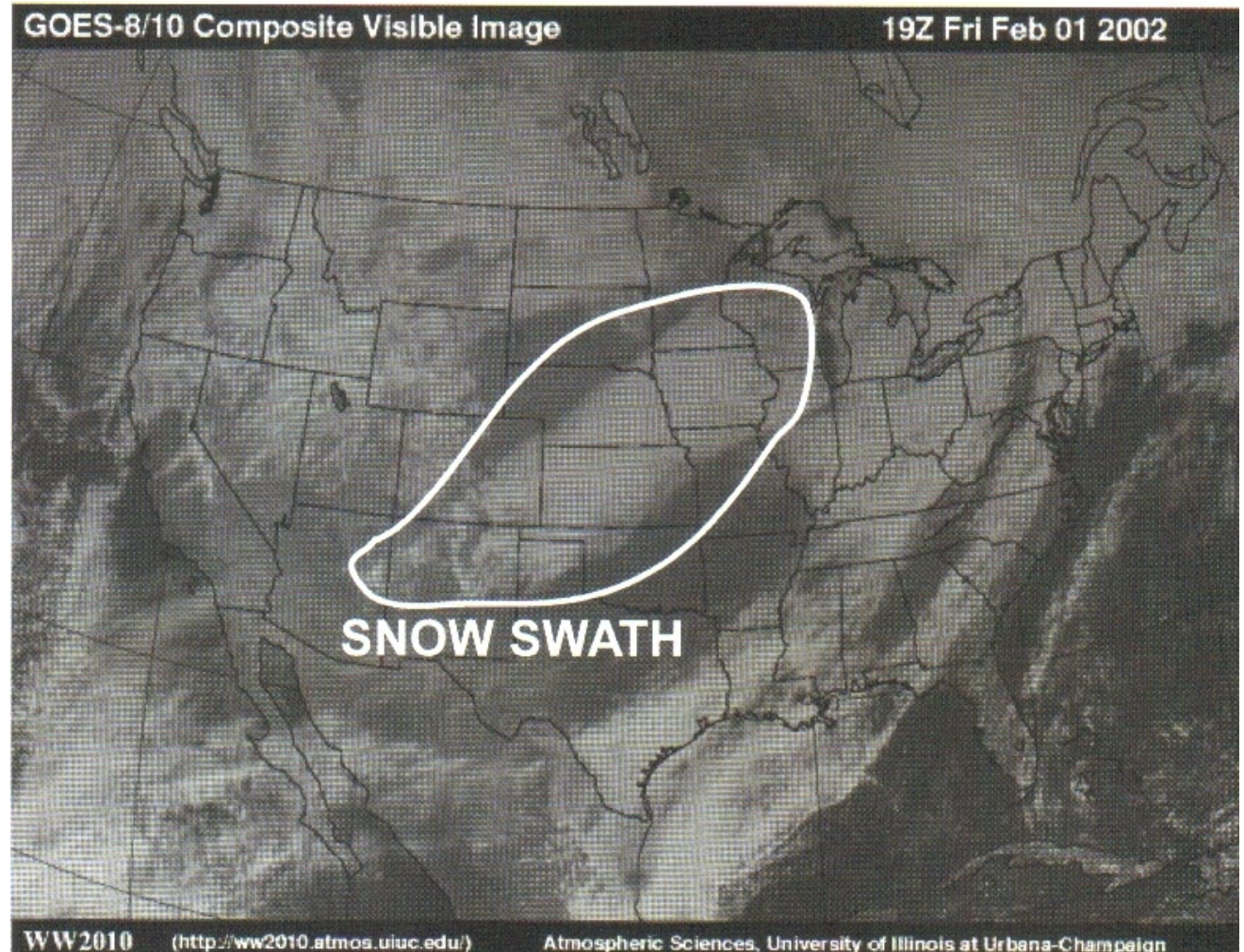


2002 Blizzard

A snow swath in
~500km wide.

Snow from the
Trowal band aloft
into very cold arctic
air, so it remains
fluffy and dry,
creating whiteouts
and huge snow
drifts at surface,
even after the
trowal airstream
passes to the east.

Drifts can be as
high as 10 to 20
feet. Snowfall can
be 10-20 inches in
a single event.

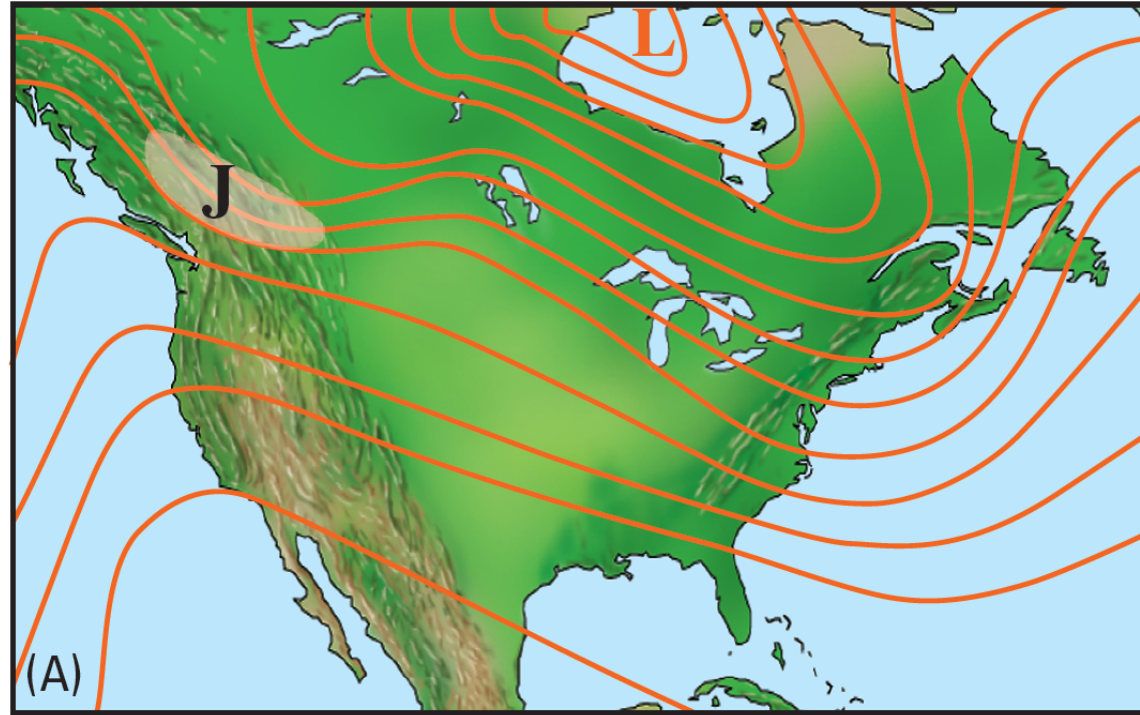


Topography Effect

- Low terrain in Mississippi River Valley (500 feet above sea level), high terrain in eastern Colorado (5000 feet above sea level)
- The rise between the Mississippi and Rockies cause the air (flowing westward north of a cyclone) climbing up
- The lifting and adiabatic cooling causes cloud formation and **enhance** snowfall rates

Alberta Clippers and Blizzards

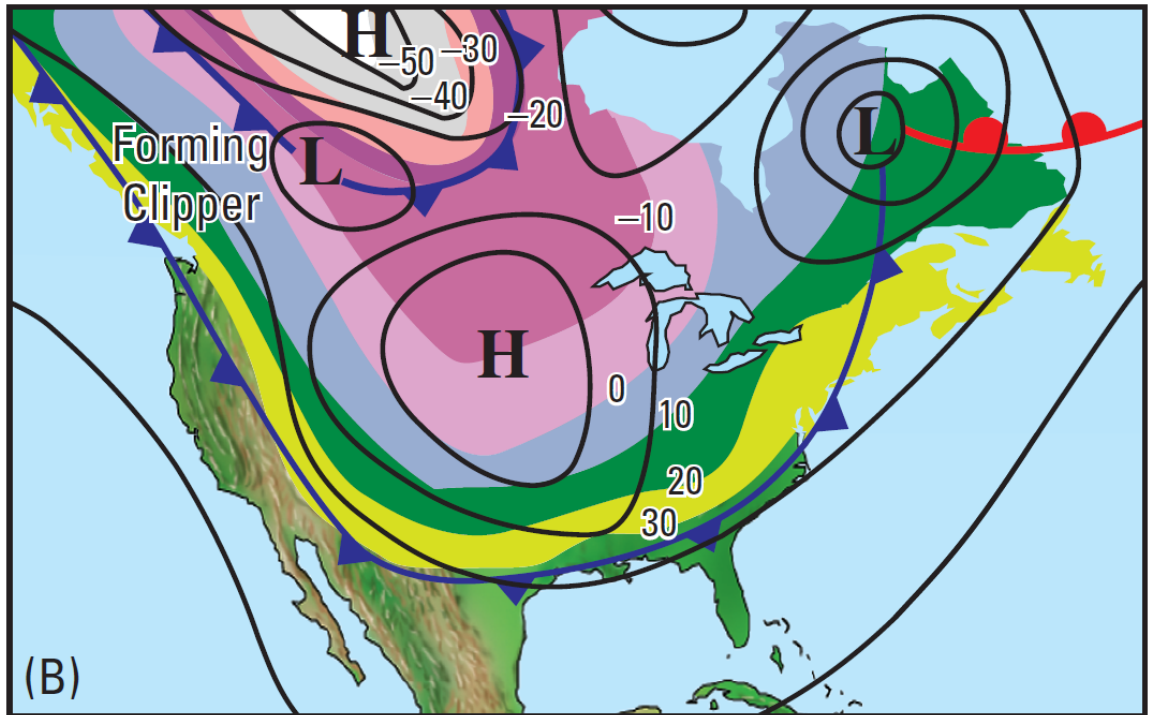
- Alberta clippers typically develop after cold air is entrenched central US and Jetstream over Canada is oriented from NW to SE
- A corresponding wave (trough) triggers the development of the Clipper cyclone
- The wave is farther north than in the case of Colorado cyclone



300 MB

Alberta Clippers and Blizzards

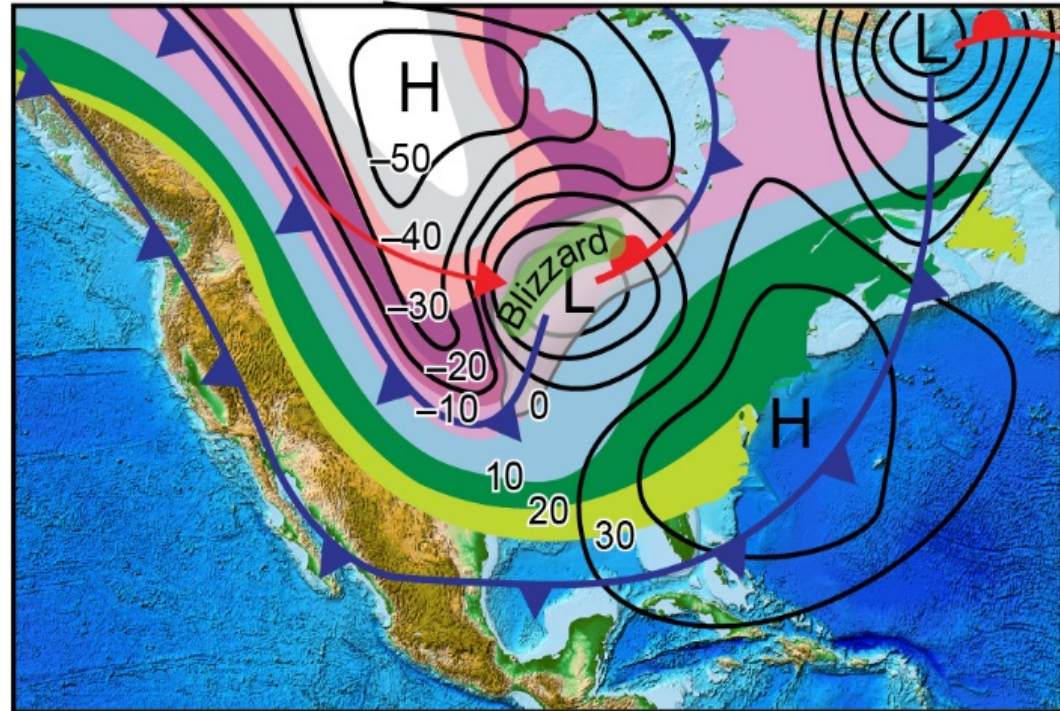
- Previous cool air over US brought by a previous cyclone
- A new Clipper forms west of the cold arctic air mass



Surface

Alberta Clippers and Blizzards

- The Clipper forms and traverses SE-ward into the Great Lake region
- A new cold arctic front forms and moves southward to the west of the cyclone center
- Temperature could be as low as $-34 \sim -40$ C behind this cold front.
- Produce less snow than Colorado cyclones (2-5 inches)
- Drifting, whiteouts, bitter cold and strong wind can be a disastrous (wind chill temperature -50 to -60 F)



**Mature Phase
(Surface)**

Winter of 1996-1997: 9 Blizzards in the Dakotas and Montana:

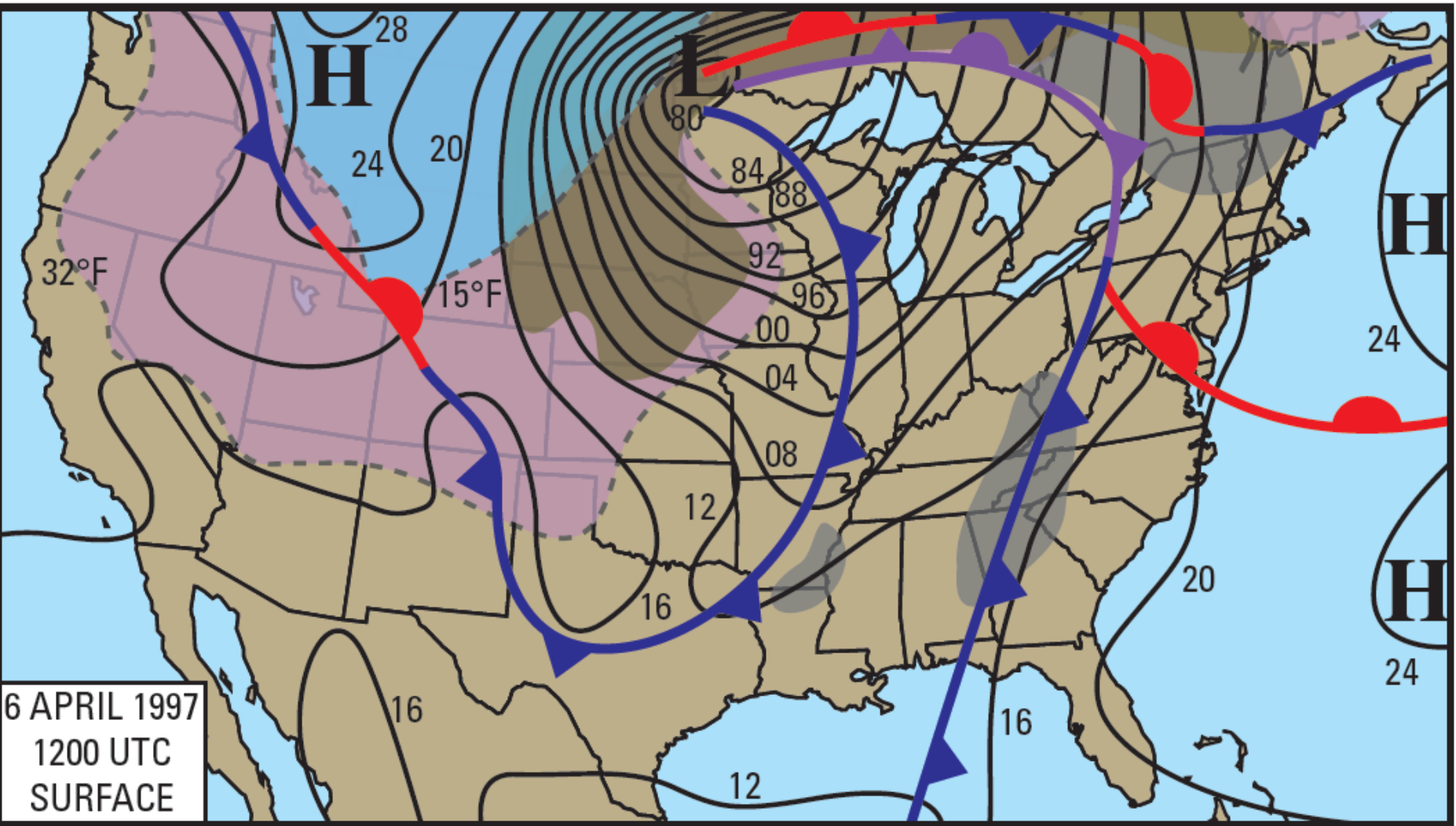
- 1st two ever presidential disaster declarations in ND.
- produced by both Alberta Clippers and Colorado cyclones.
- Fargo ND received 117 inches of snow in total.
- Average one blizzards per week between 12/15/96-01/24/97

Table 14A Summary of Surface Data at Fargo, North Dakota, during Nine Blizzards in the 1996-97 Winter

Date of Blizzard (1996-97)	Lowest Temperature (°F)	Highest Temperature (°F)	Greatest Hourly Sustained Wind (knots)	Fasted Reported Wind Gusts (knots)	Snowfall (inches)
16-17 November	9	26	34	42	13.5
16-18 December	-8	22	33	43	7.9
23 December	-14	-8	21	—	4.9
4-5 January	0	20	33	40	10.7
9-11 January	-15	15	24	35	4.8
15 January	-8	12	38	49	1.0
22-23 January	-17	24	34	—	4.9
3-4 March	-5	31	25	—	15.5
5-6 April	9	38	24	56	7.0



Final blizzard in the Winter of 1996-1997 in the Dakotas and Montana:
Extremely strong pressure gradient over ND. Winds >58mph; 16-24 inches of snow; \$21.5 million in damage to farm structures and milk wasting; Red River flooding inundating the cities of Grand Forks and Fargo



Ground Blizzard: blizzards caused solely by blowing snow



Ground Blizzard Negaunee, MI

Ground Blizzards

- The sky is clear, but extremely cold winds blow across snow-covered ground
- Frequent on the Great Plains in the wake of snow storms
- Mainly in small regions prone to drifting and high winds
- Shallow (2-10 m) layer of blowing---previously fallen ---snow when it is very cold.
- Bad road conditions including black ice
- Very dangerous because they are unexpected, occurring after the storm has passed.

Snow Rollers: an interesting phenomena blizzards leave behind



A five-pound snow roller



Blizzard Safety

- Bad road condition cause disasters
- Car stranded on roadside
- People die of hypothermia while seeking help or carbon monoxide poisoning while running the car's engine for warmth
- When snow is blowing, you can feel a lot colder than the wind chill temperature (which doesn't take into account heat loss through melting and evaporation)



Blizzard Safety

Stay in your car

Don't die from hypothermia or CO poisoning

A single candle can keep you warm

Travelers should bring:

Survival kit: Sleeping bag; flashlight & batteries, a first aid kit, a knife, Food & Water ; extra dry clothing, Pail for waste; a small-can for melting snow for additional drinking water; Cell phone; Candles; water-proof matches

Winter Automobile Safety items: a sack of sand or car litter, a shovel, a windshield-scraper, and brush, a tool kit, a tow rope, booster cables, and accident flares

Summary

- Blizzard: Gale force winds (>35 kt) and visibility in blowing snow less than $\frac{1}{4}$ mi (500 m) and last > 3 h
- Common (> 1 per year) in Great Plains of US & Canada, Siberia ...
- Arctic front pushes south behind a polar front that is already far south.
 - Lee cyclogenesis (Alberta Clipper) and arctic high in southern Canada
 - TROWAL provides moisture for snow
- Survival: Be able to wait it out