Deadly Wind Storm (extracted from EDMONTON SUN)

“A snow-kite sailing trip across frozen Lac St. Anne ended in tragedy yesterday when 100-km/h winds slammed a man and his snowboard into the side of an abandoned church... the man was caught in severe winds that swept through a strip of central Alberta, stretching from Edson to the Saskatchewan border which felled trees, toppled a radio tower, flipped small planes, tore up roofs and knocked out power to more than 29,000 people.

At Rabbit Hill, gusts derailed one of the chairlifts, forcing the rescue of 45 people who were on the lift at the time... "That burst of wind came up so fast on us, there was no opportunity to offload the chair."

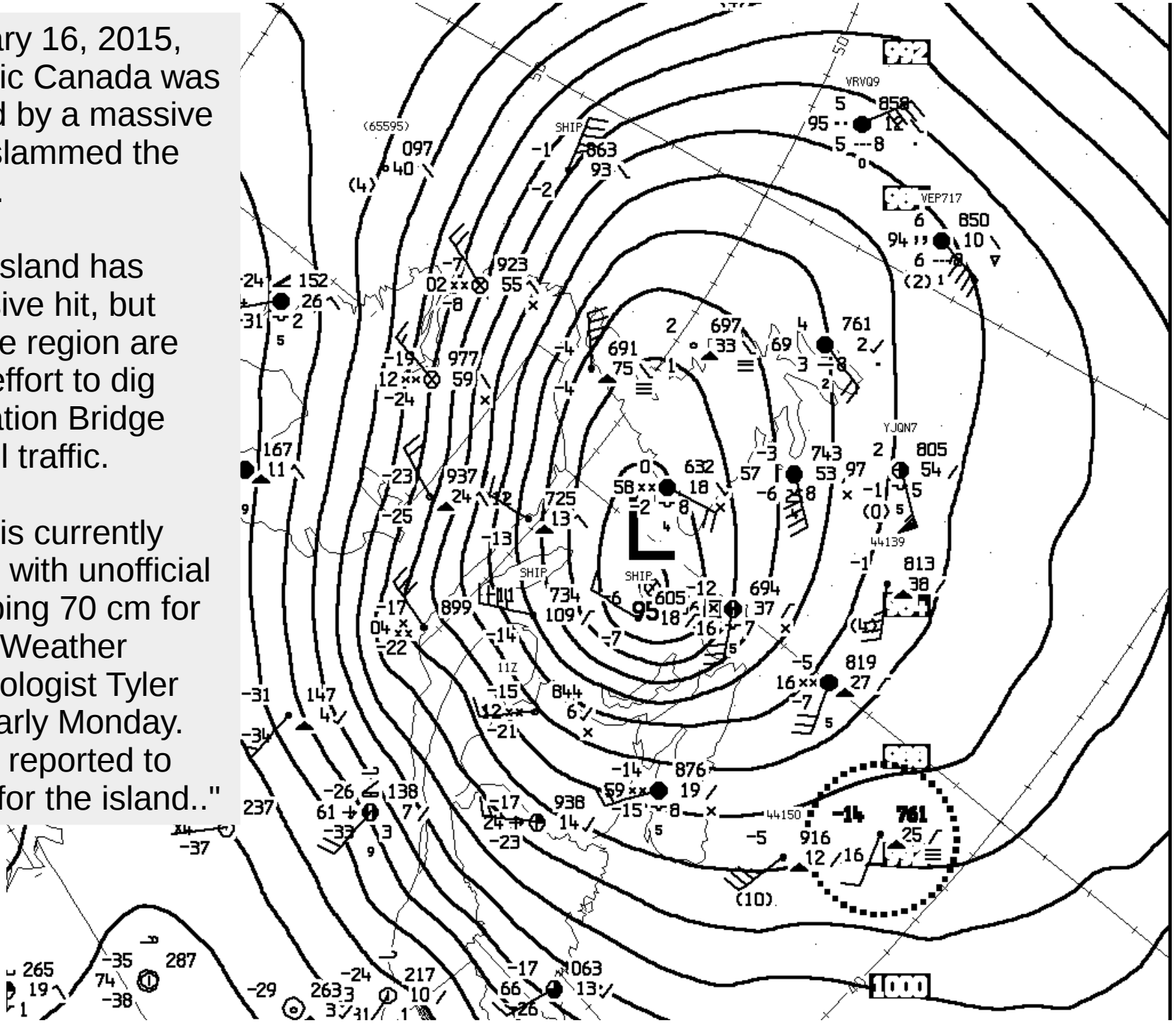
Winds between 70 and 100 km/h slammed into the city about 12:15** p.m.

Review – isobars & winds. Civic holiday east coast storm Mon 16 Feb. 2015

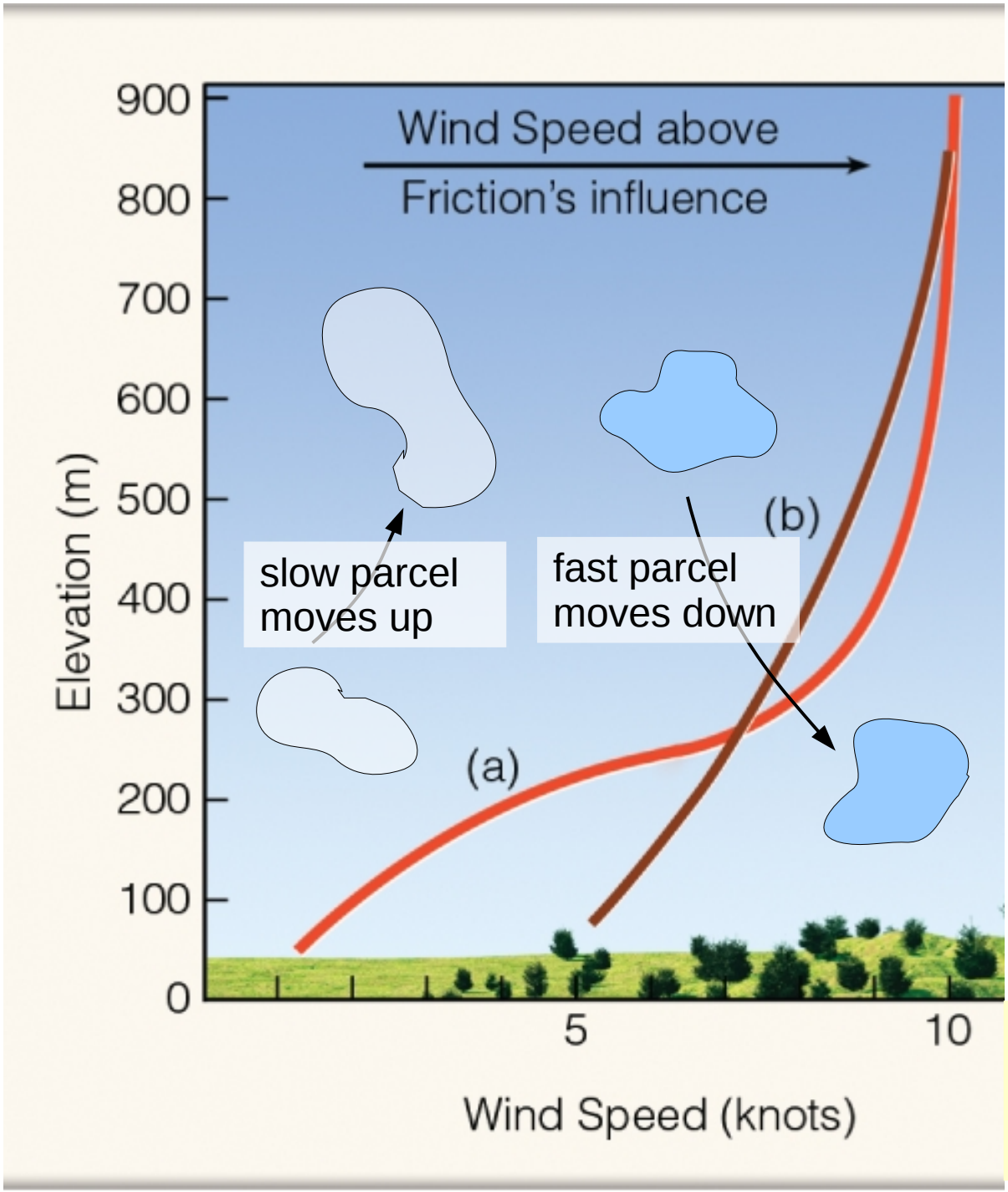
Monday, February 16, 2015, 7:21 AM - Atlantic Canada was all but paralyzed by a massive nor'easter that slammed the region Sunday...

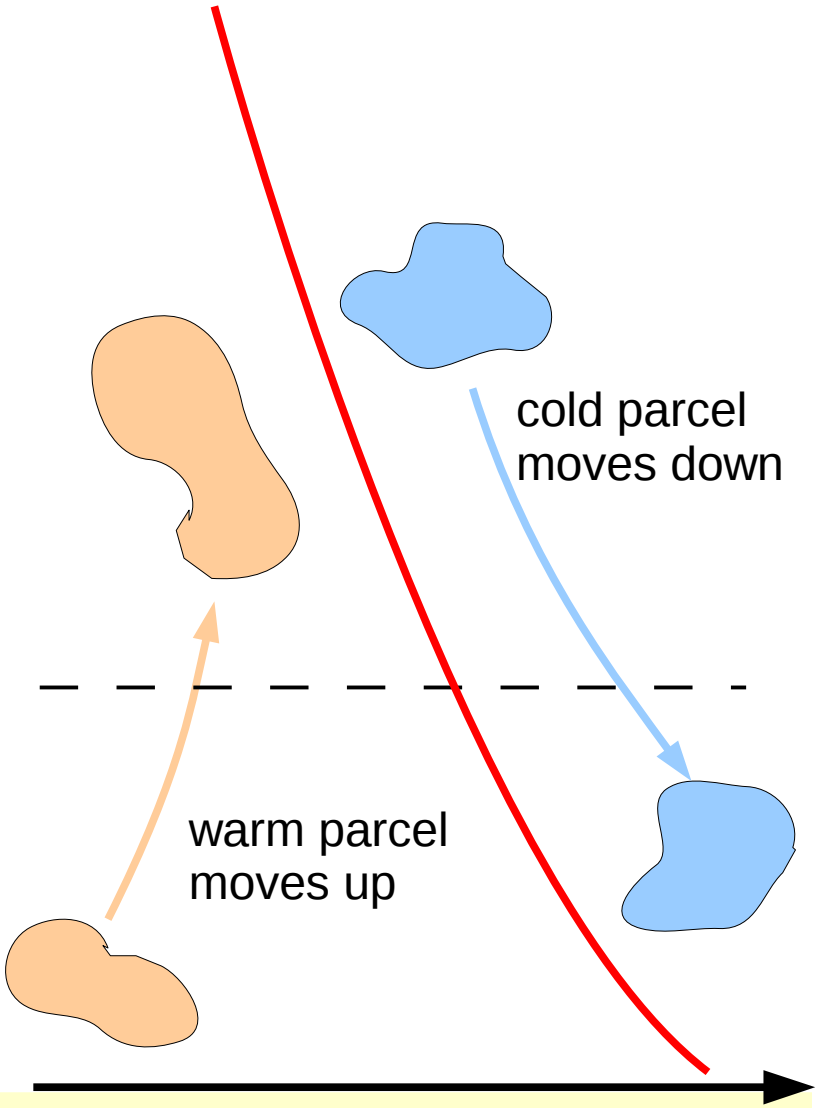
Prince Edward Island has suffered a massive hit, but other parts of the region are facing a titanic effort to dig out... Confederation Bridge was closed to all traffic.

"The nor'easter is currently pummeling PEI, with unofficial snow totals topping 70 cm for Charlottetown," Weather Network meteorologist Tyler Hamilton said early Monday. "Wind gusts are reported to hurricane force for the island.."



Review: wind & temperature profiles, and the effect of vertical mixing

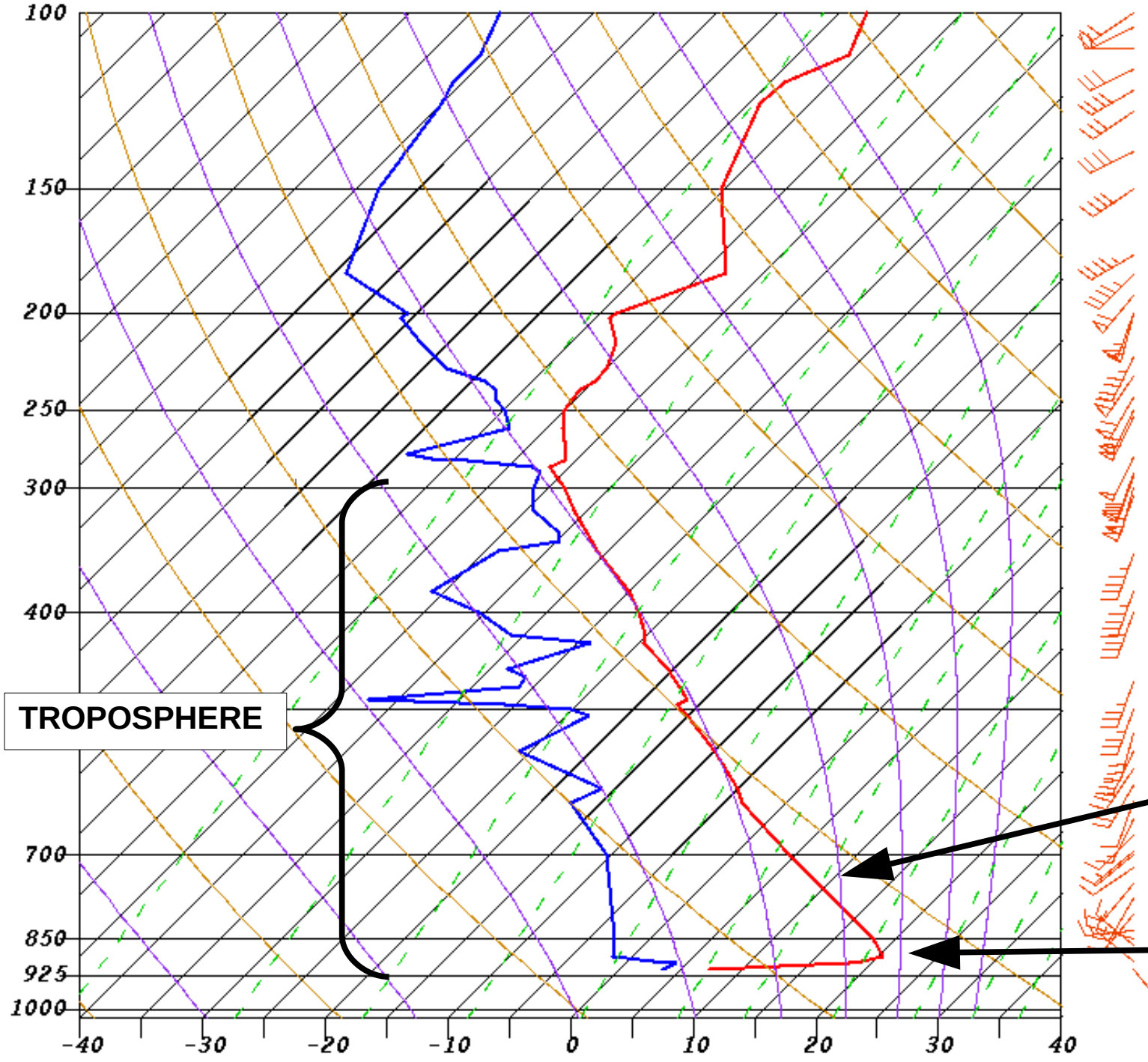




Temperature

(Daytime scenario)

“Summer-type” troposphere, Stony Plain 06 MDT Sat. 21 Sept. 3013

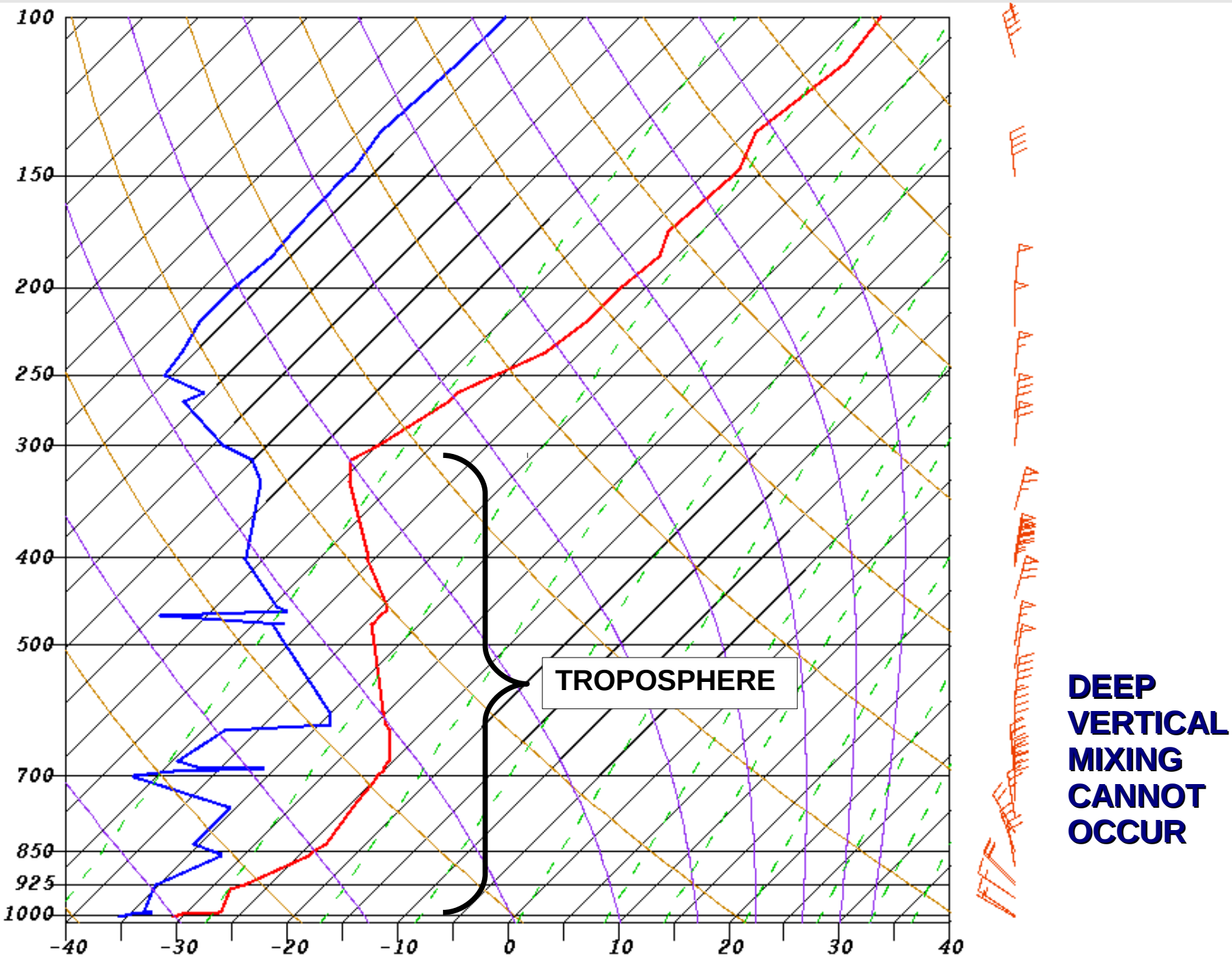


STRONG VERTICAL MIXING EXPECTED TO OCCUR DURING THE DAY

AT THE TIME OF THE SOUNDING WINDS LIGHT AT SURFACE, STRONG ALOFT

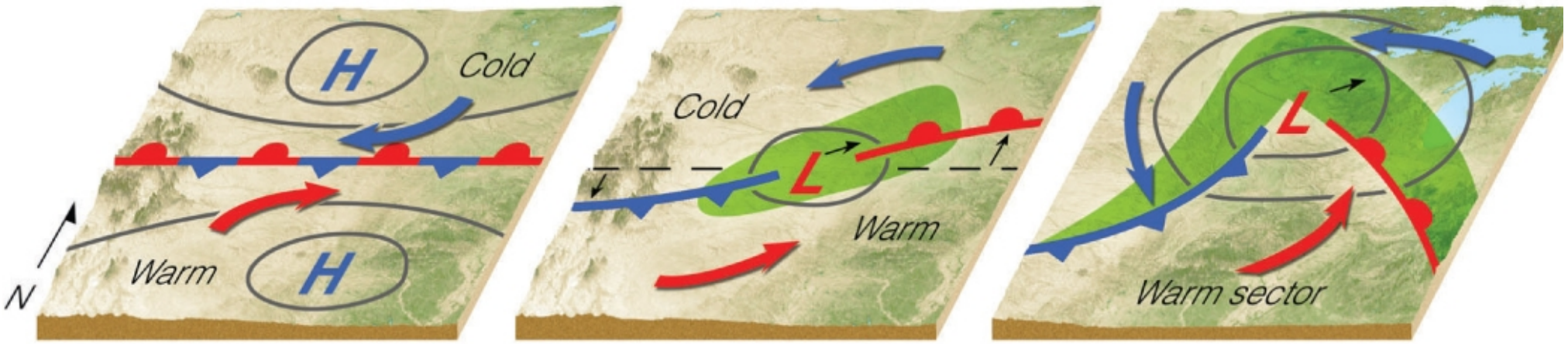
MIXING WILL INCREASE SURFACE WINDS

“Winter-type” troposphere, The Pas (Manitoba) 06 CST Sun. 22 Feb. 2015



DEEP VERTICAL MIXING CANNOT OCCUR

Polar Front Model: are fronts relevant in the context of extreme winds?



(a) Stationary front (b) Frontal wave (c) Open wave

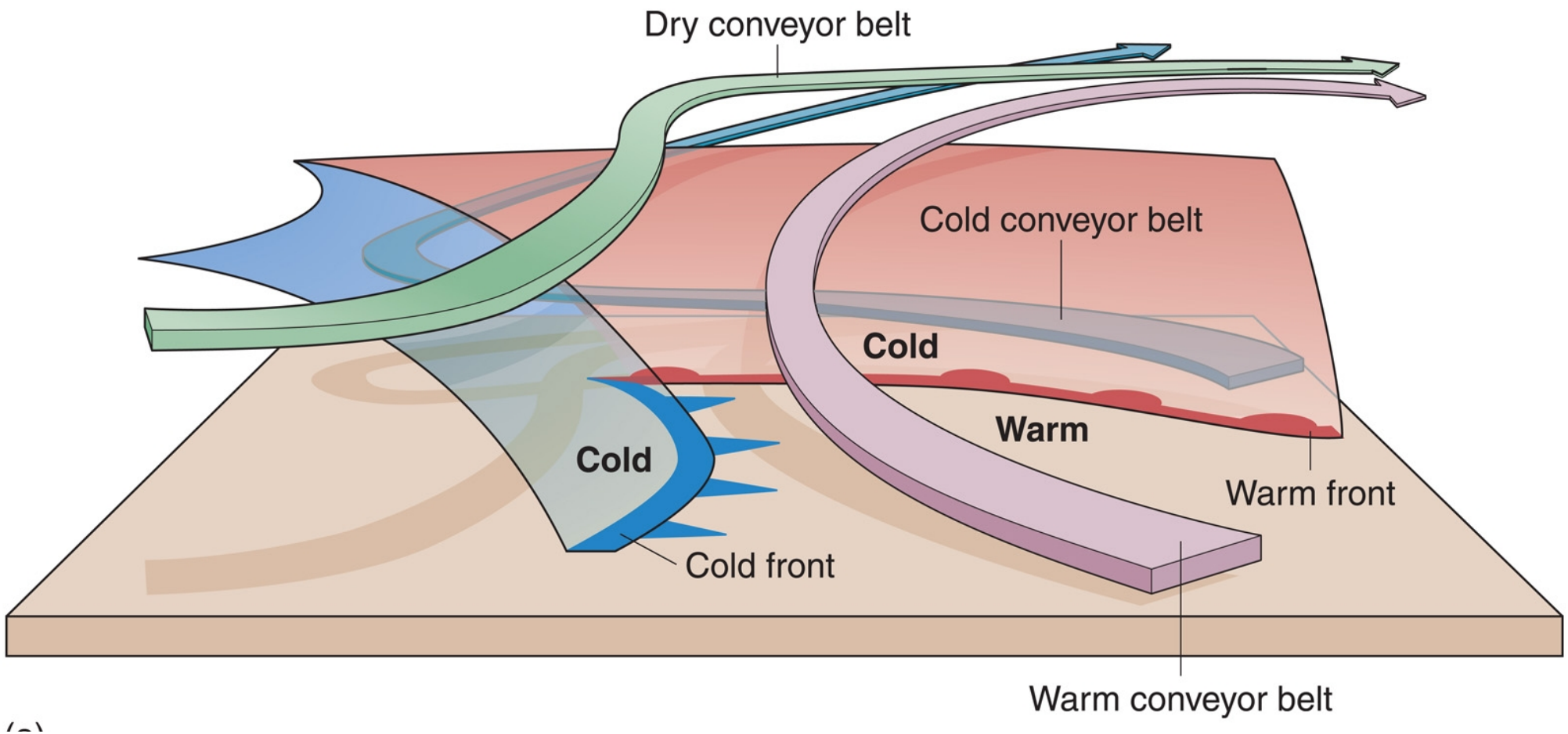
Quasi-stationary polar front lies along trough; wind shear; grav. potential energy

kink forms – “frontal wave” or “incipient cyclone” – precip begins – latent heat

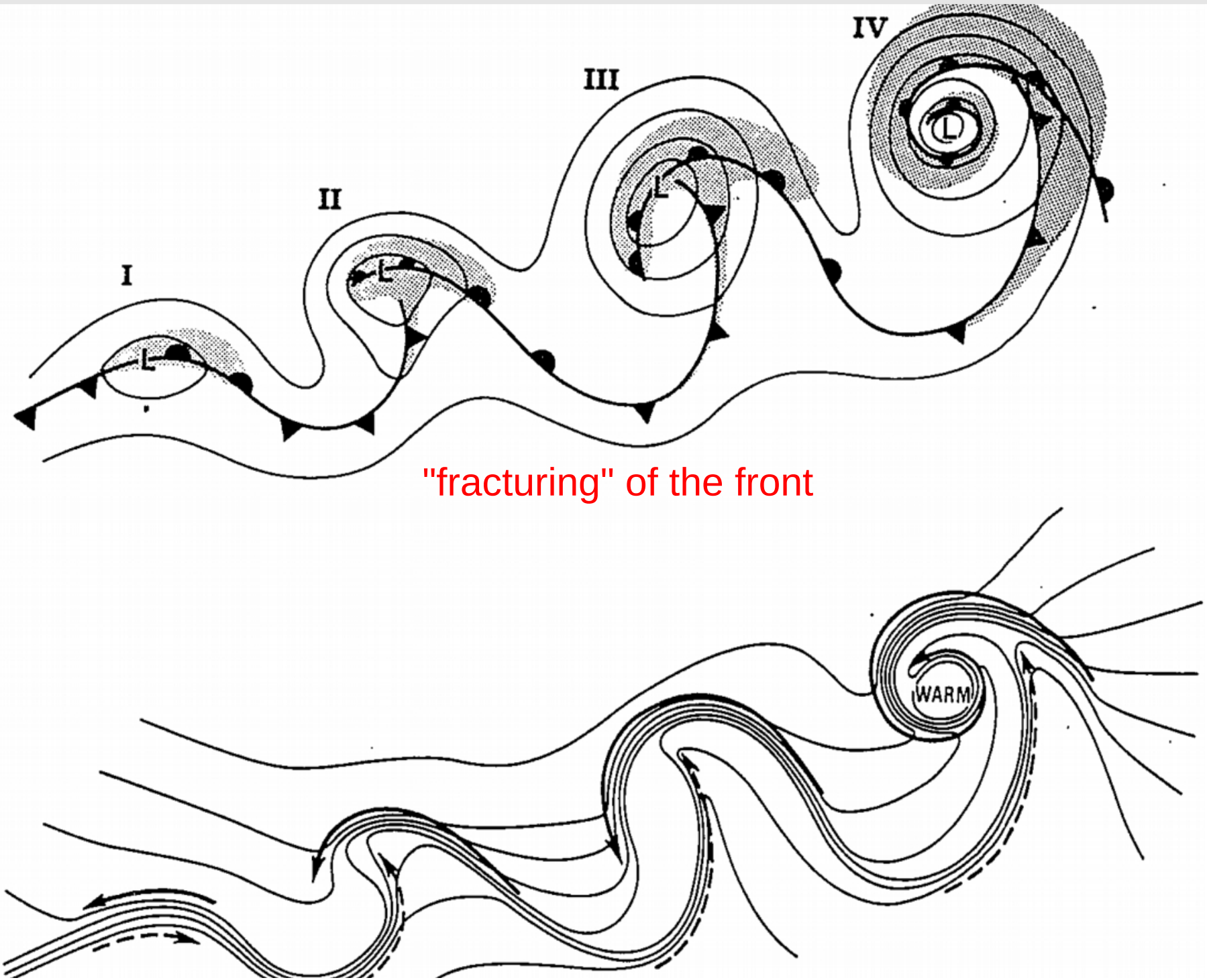
fully-developed “open wave”; warm sector

Conveyor belt model of middle-latitude cyclone

- CCB and WCB could be associated with strong surface winds

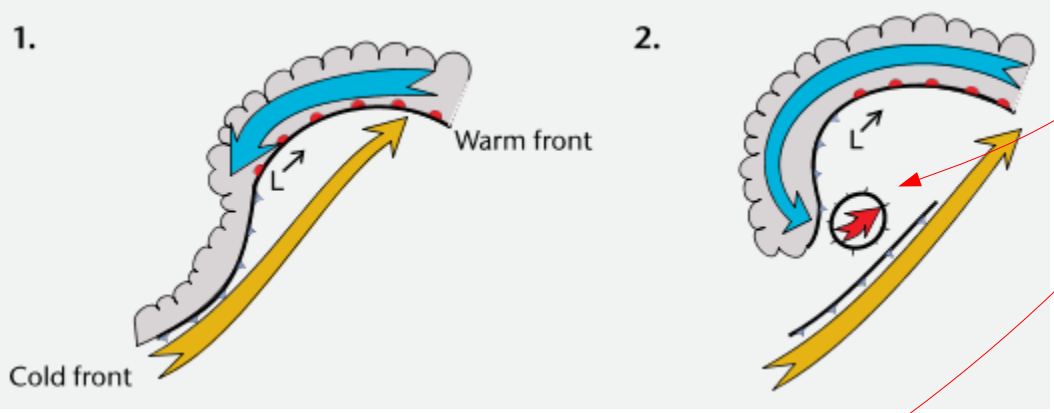


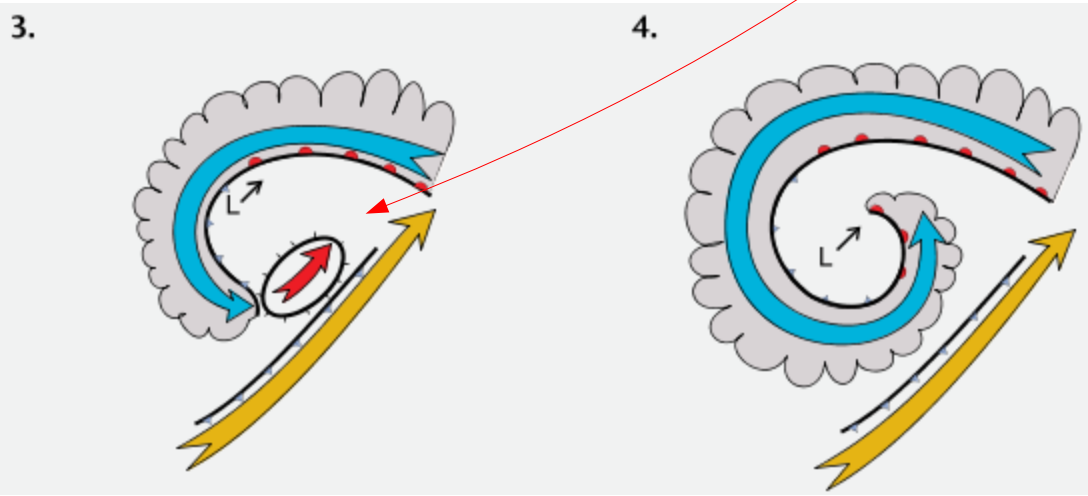
Shapiro & Keyser proposition: slightly revised life cycle of midlatitude storm

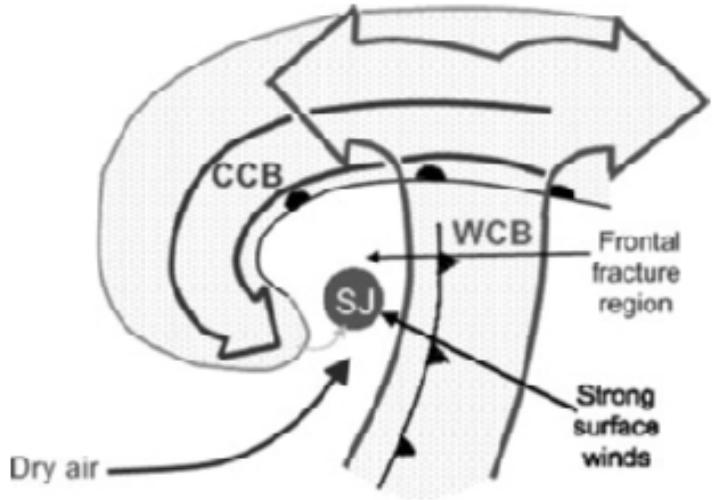


Strong winds associated with the “Sting Jet” of middle-latitude cyclone

- recent work has associated severe winds with a "sting jet" caused by the **Dry Conveyor Belt's descent to the surface**, i.e. air from several km aloft descends for several hours, cooled by evaporation of rain or snow that falls into it. Negative buoyancy may accelerate this jet to > 150 km/hr

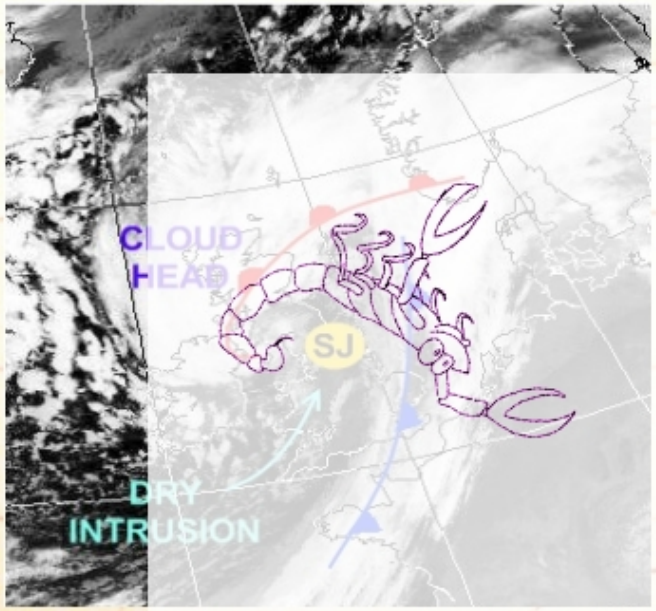






Raises question: did the sudden gusts of the 19 Dec. storm occur before or after arrival of the cold front?

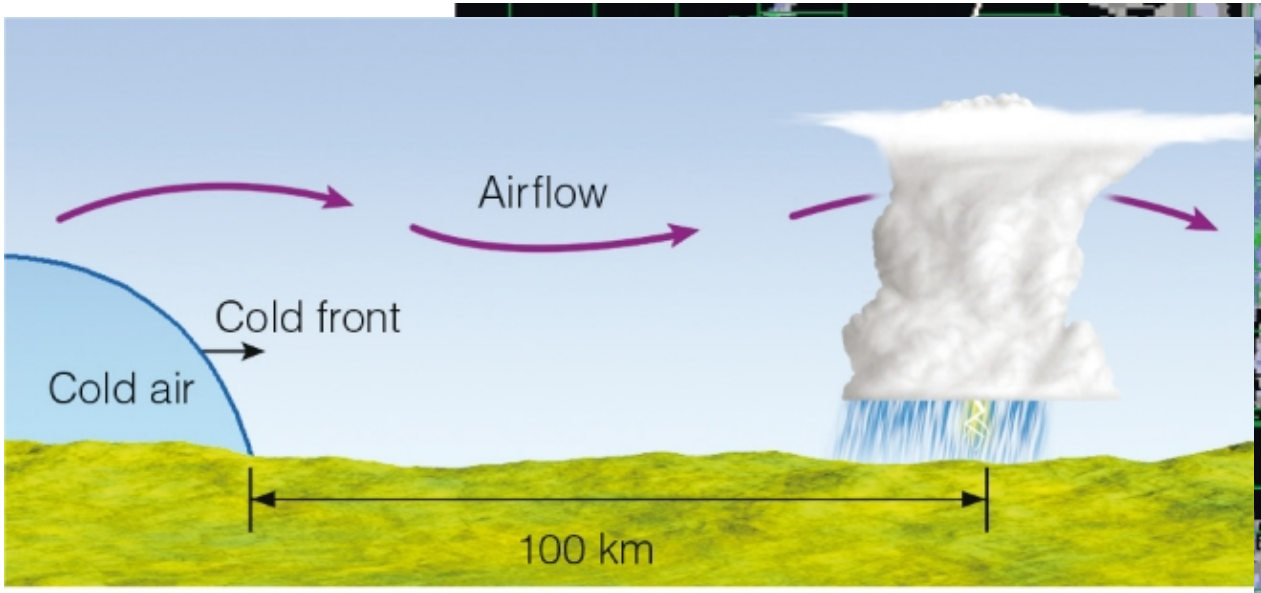
Hannah Parker, **Neil Hart**
Suzanne Gray and Peter Clark
University of Reading



Some produce windstorms

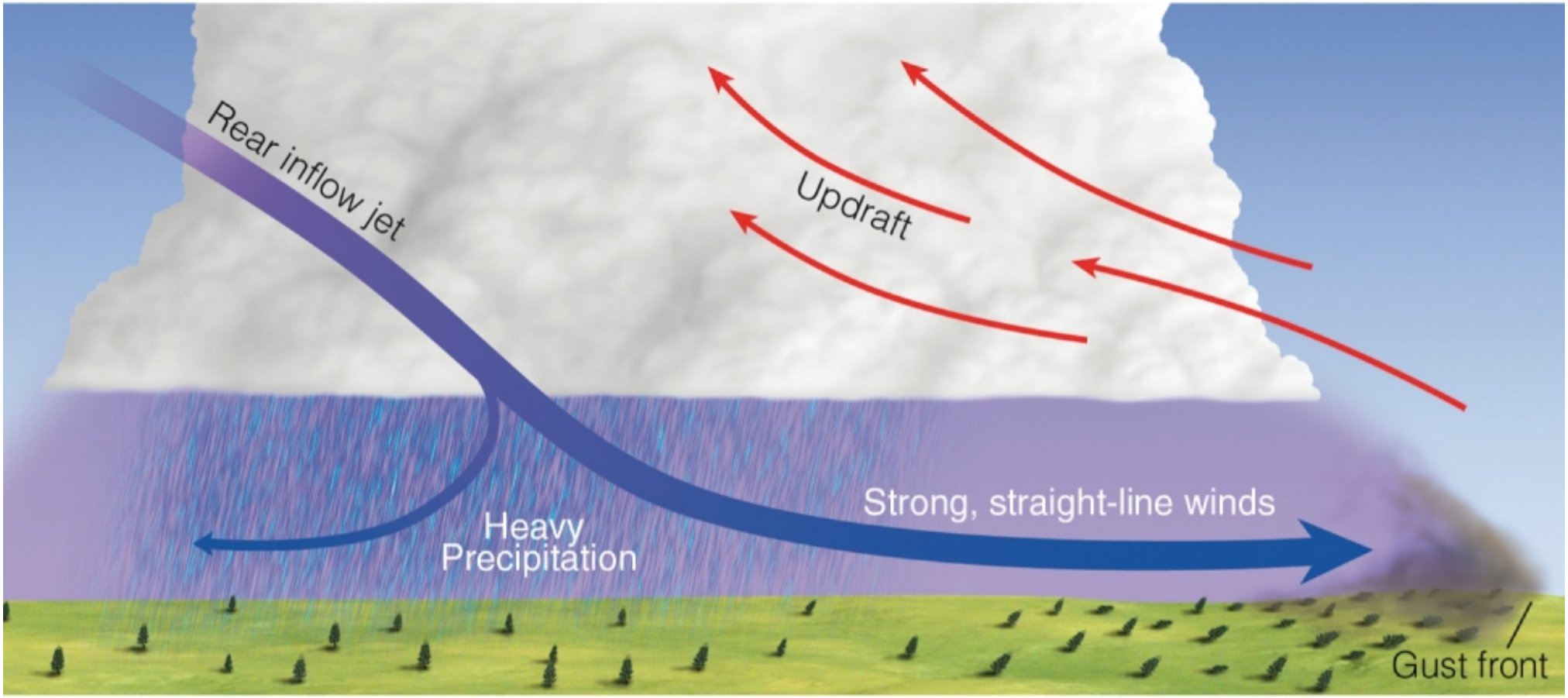
http://www.met.reading.ac.uk/~rb904381/ExeterWind2013_NeilHart.pdf

Surface winds asssociated with pre-frontal squall-line thunderstorms



- squall line along a cold front *or* in the warm air 100-300 km ahead of the cold front
- squall-line may extend over hundreds of km

Strong winds associated with severe convection



Last slide of the REVIEW phase of lecture: Gust front and shelf cloud

Downdraft produces gust front, associated with which may see shelf cloud (“arcus”) and occasionally roll cloud

19th December 2004 wind storm in Central Alberta

"Yesterday (Dec. 19, 2004) a man from Alberta Beach was killed while kiting alone on the lake when hit by a huge wind storm... *that* … swept across the lake around noon.

Winds prior to storm gusty 30km/hr, the sky clear, temps were warm and rising.

Storm gave almost no warning, from the time clouds became visible on the horizon to the time it hit was 15 mins or less. When the storm hit **winds increased from 30km/hr to over 110km/hr in 20 seconds or less**... cars flipped over, roofs ripped from..."

Squall line** approaching Edmonton International Airport around 12.25 pm. The **temperature was +8°C at the time**, winds out of the southwest at 14 kt (25 km/h). The convective squall line came through the airport at 12:27 pm with a peak gust of 100 km/h out of the northwest at 12:33 pm.

**a line of active thunderstorms... a type of mesoscale convective system distinguished from other types by a larger length-to-width ratio (Am. Met. Soc. Glossary)

TIMELINE – 19th December 2004 wind storm in Central Alberta

1630Z - 1700Z (9:30 - 10 am MST) convection develops over eastern BC

1719Z (10:19 am) line of thunderstorms west of Edson, lightning, hail, rain, snow

1800Z (11:00 am) convective line crosses Edson and Whitecourt 90 km/h gusts

1805Z (11:05 am) Special weather statement issued for areas west of Edmonton

1820Z (11:20 am) line crosses Mayerthorpe 100 km/h winds

1827Z (11:27 am) Wind Warning west & north of Edmonton gusts to 100 km/h

1850Z (11:50 am) Wind Warning extended to Edmonton City and regions east

1850Z (11:50 am) fatality in Alberta Beach, kiteboarder blown by strong winds

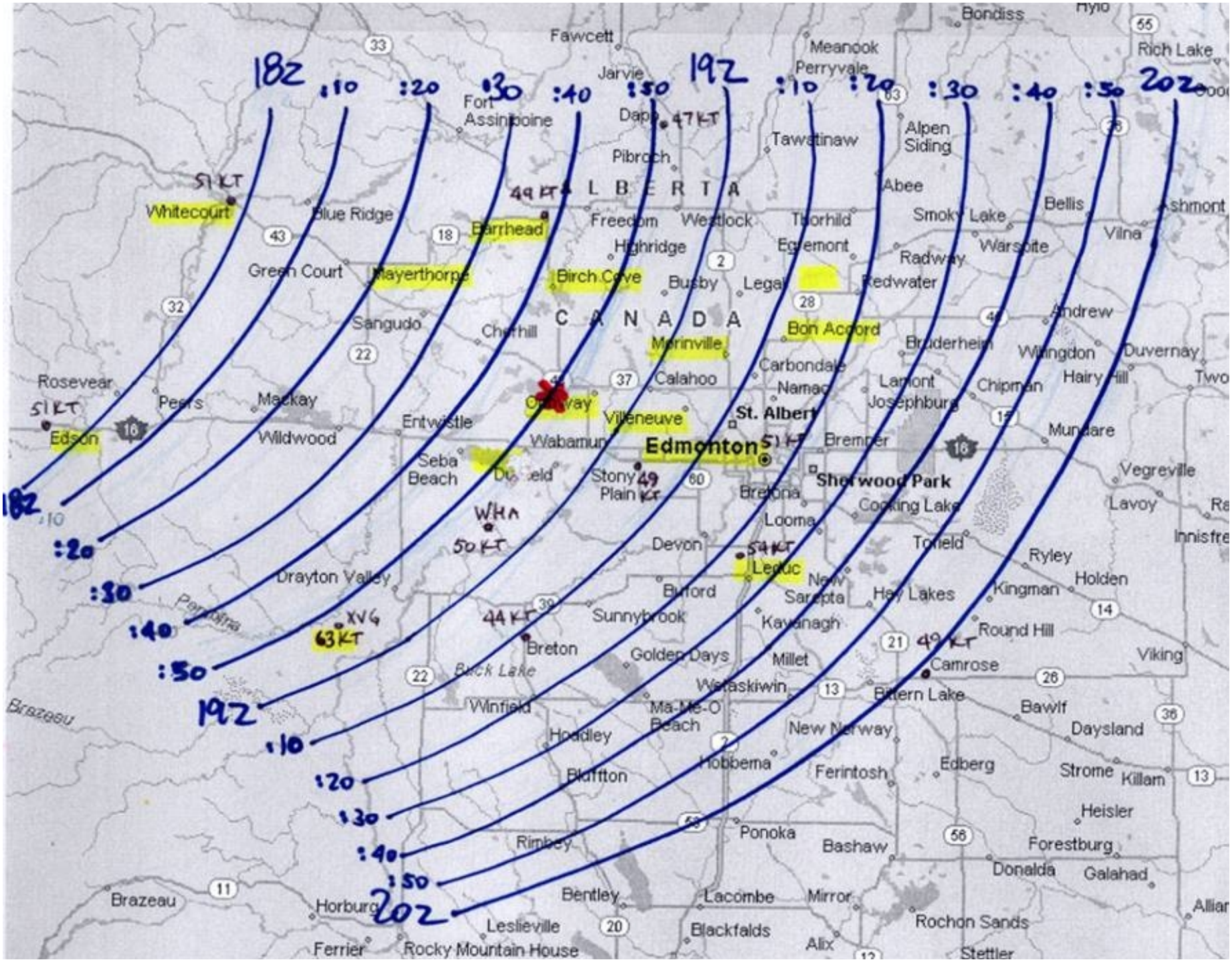
1905Z (12:05 pm) planes flipped at Villeneuve airport

1915Z (12:15 pm) line crosses the city of Edmonton 100 km/hr gusts

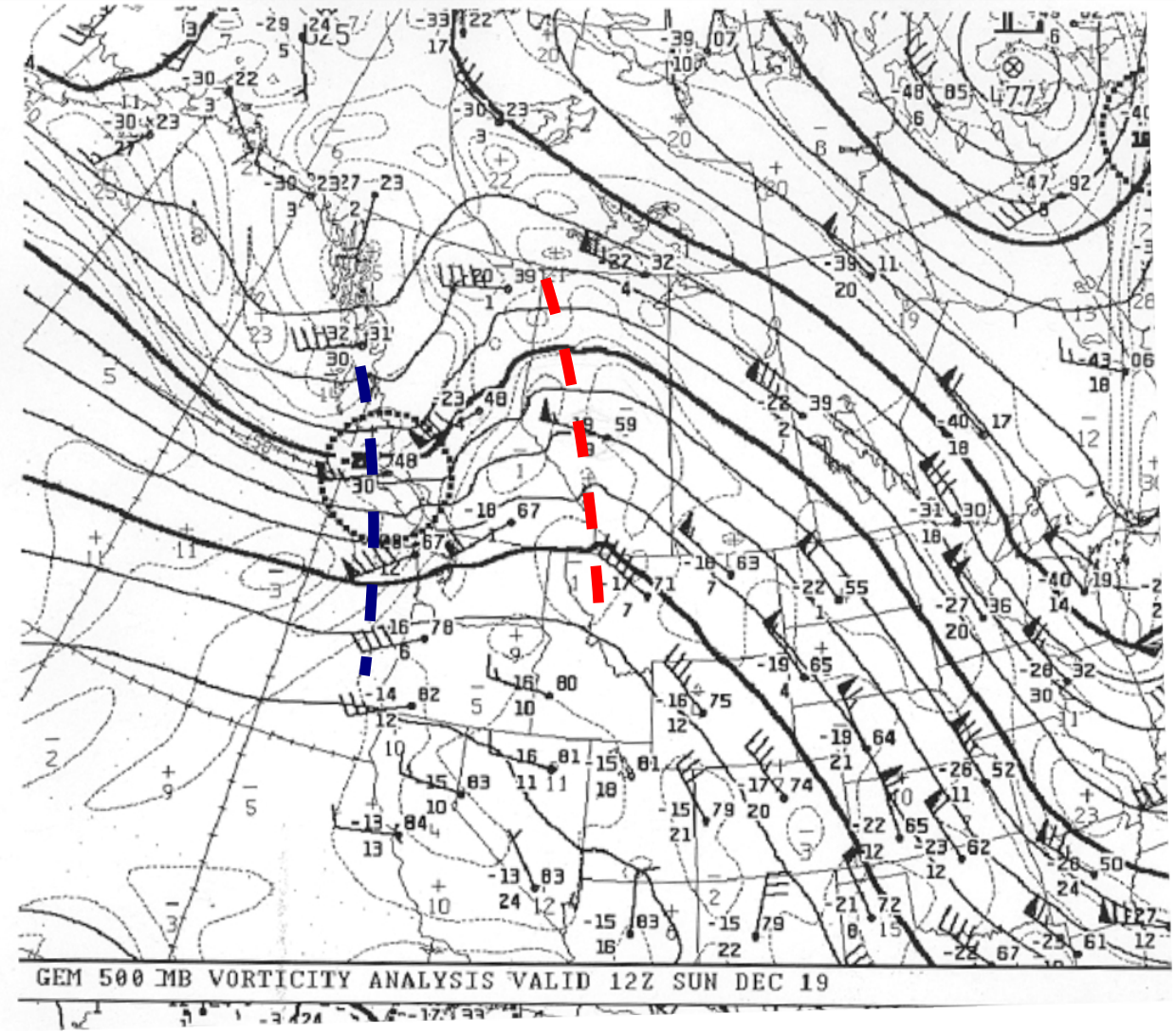
1930Z (12:30 pm) 100 km/hr wind gust reported at Edmonton International Airport

2000Z (1:00 pm) line crosses Camrose with 90 km/hr wind gust

The 19th December 2004 wind storm in Central Alberta

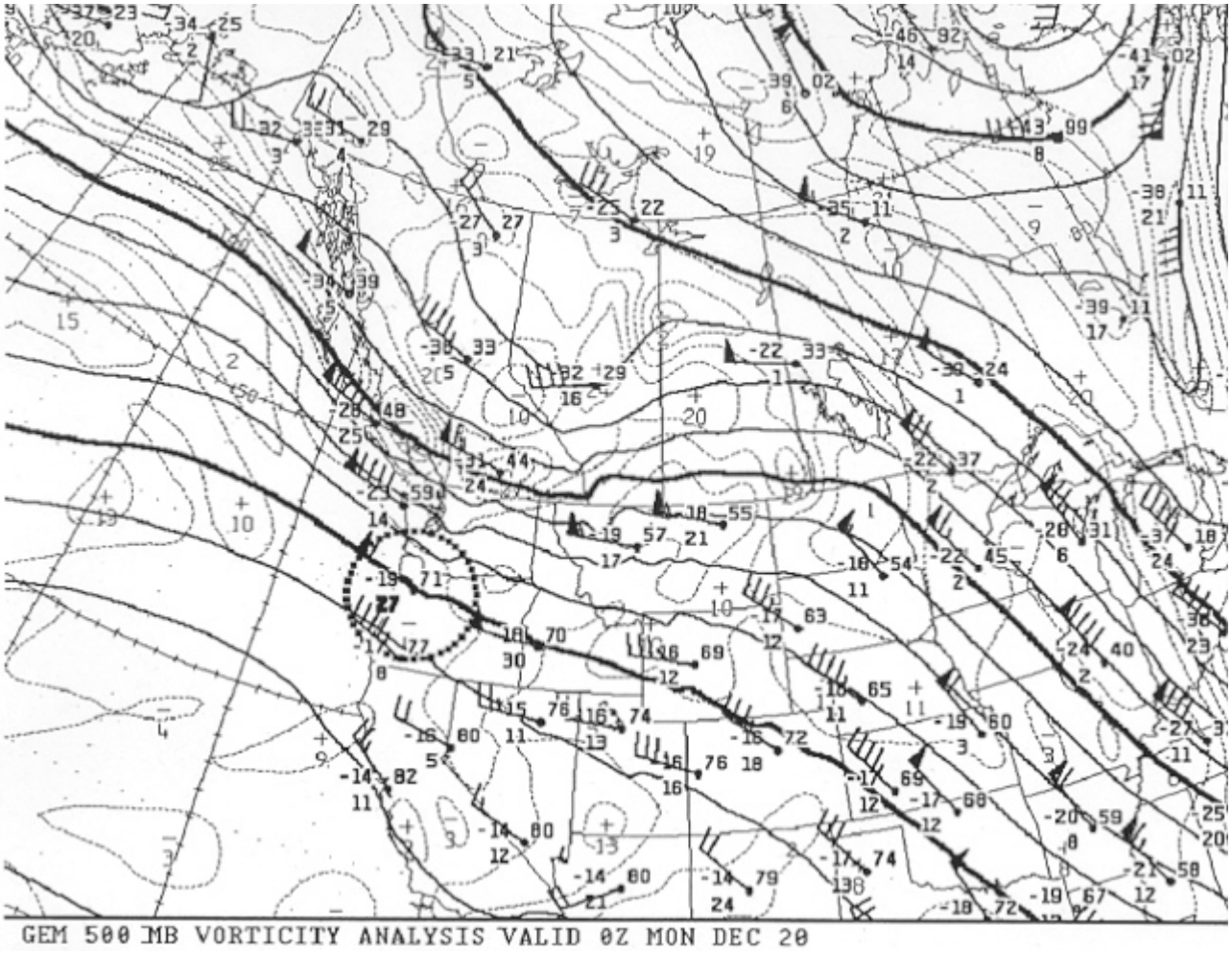


500 hPa analysis 05 MST SUN 19 Dec.



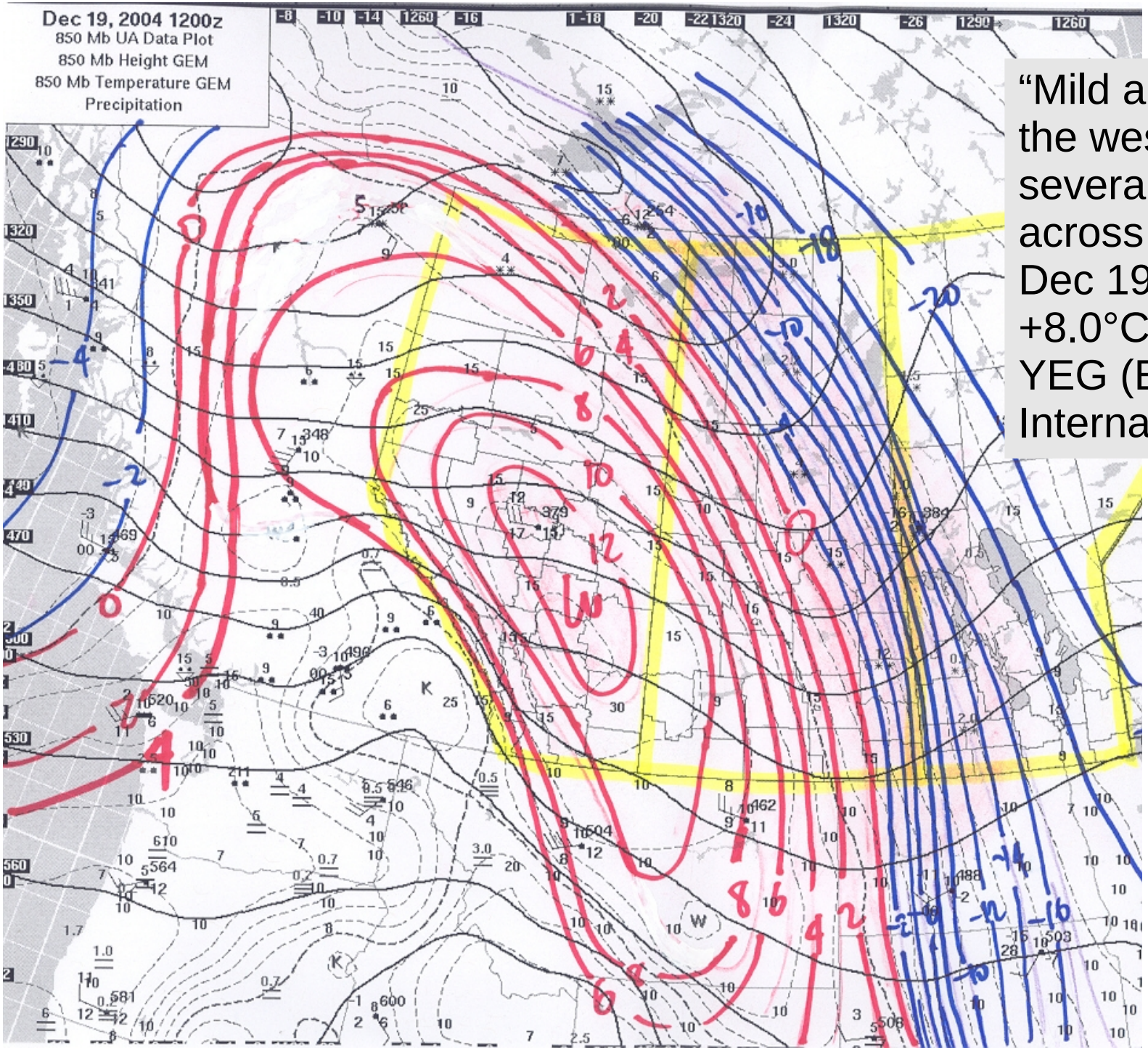
- Strong SW wind over the Rockies
- **Trough** on the coast is digging into **ridge** over AB

500 hPa analysis 17 MST SUN 19 Dec.



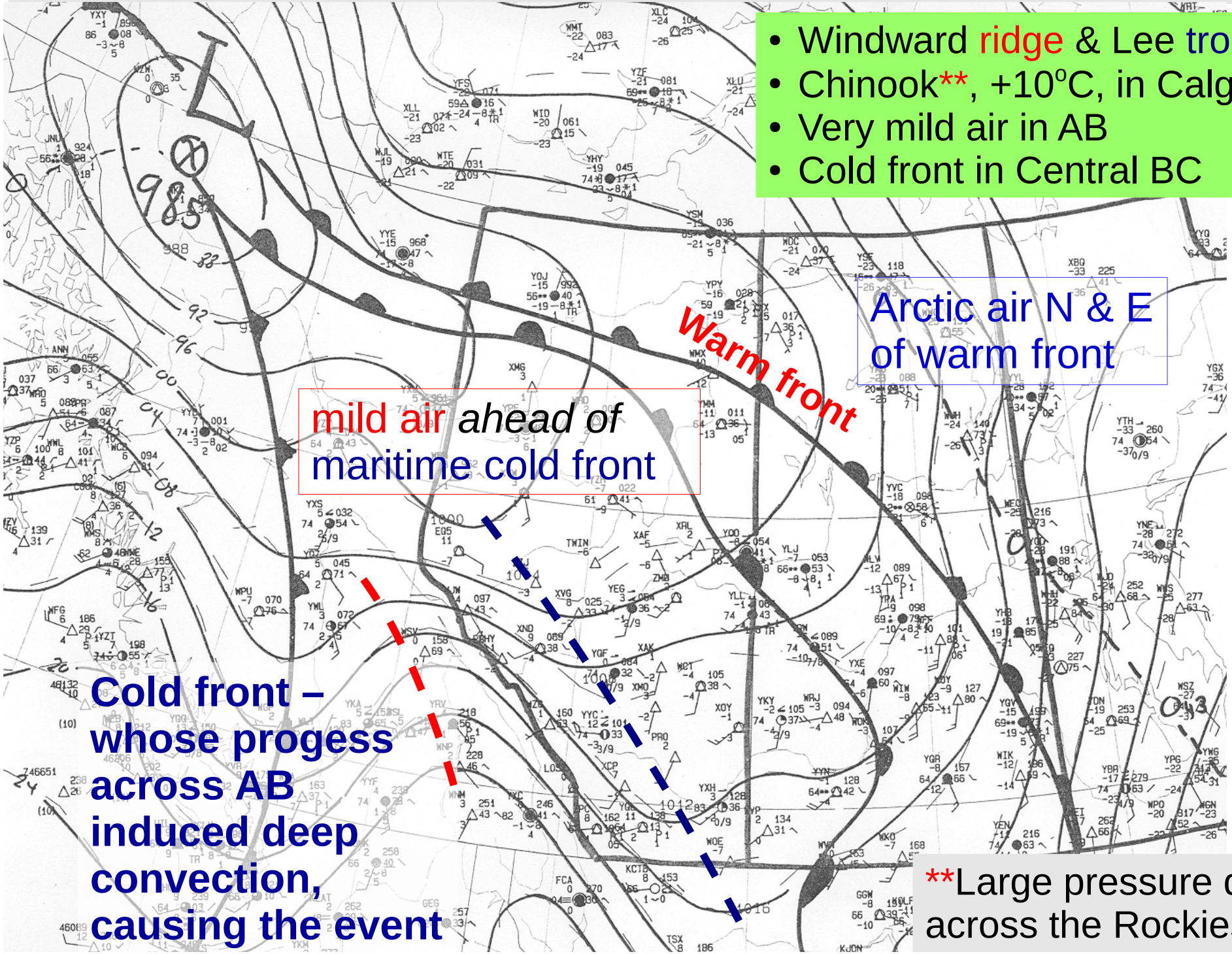
- In 12h, the trough has moved over C. Alberta

850 hPa analysis 05 MST SUN 19 Dec.

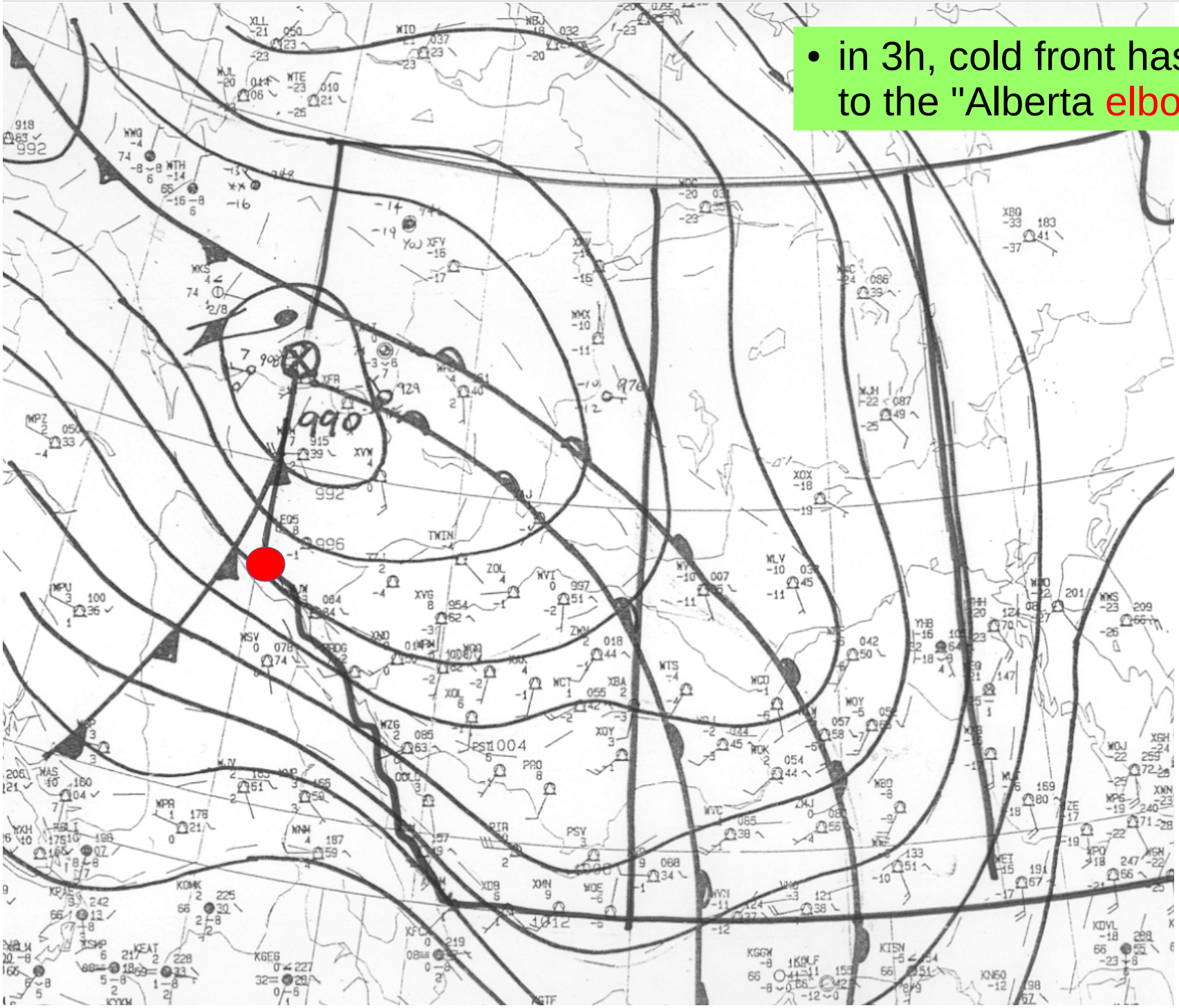


"Mild airmass over the west helped set several record highs across Alberta for Dec 19th, including a +8.0°C reading at YEG (Edmonton International)"

The Dec. 2004 wind storm: surface analysis 12Z (05 MST) Dec. 19

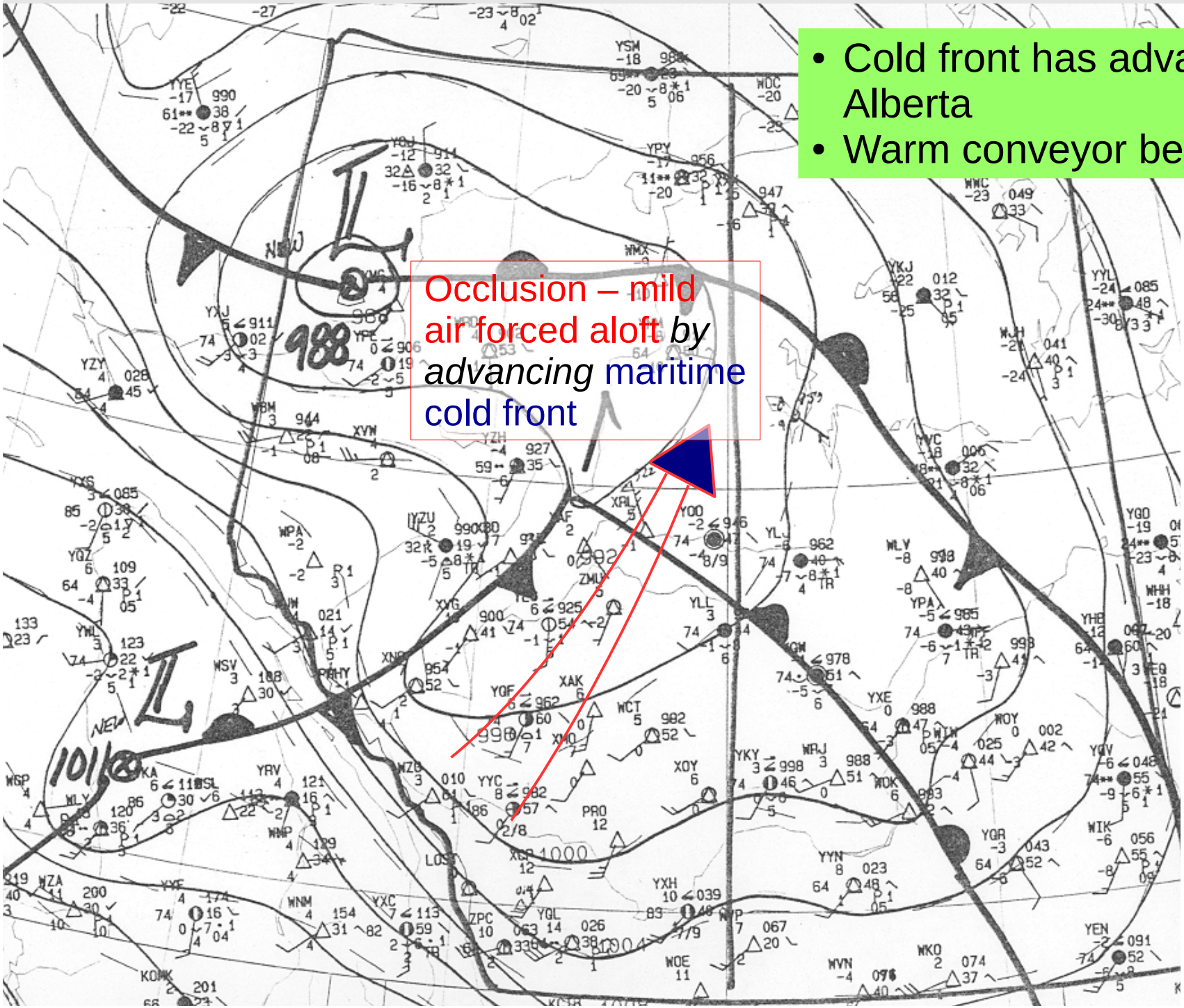


The Dec. 2004 wind storm: surface analysis 15Z (08 MST) Dec. 19



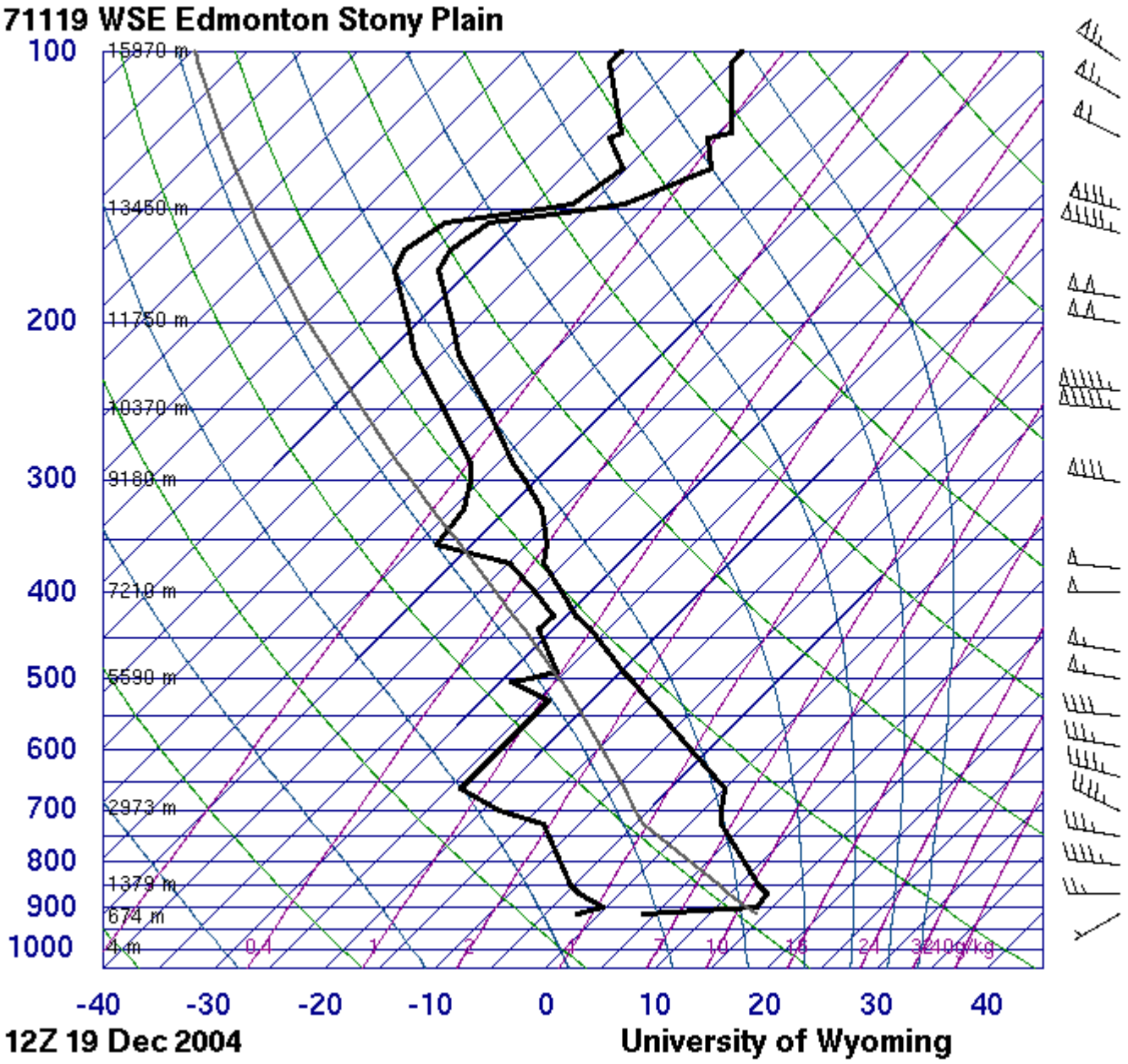
- in 3h, cold front has advanced to the "Alberta elbow"

The Dec. 2004 wind storm: surface analysis 18Z (11 MST) Dec. 19



- Cold front has advanced to C. Alberta
- Warm conveyor belt?

Edmonton sounding before the storm: 12Z (05 MST) Dec. 19

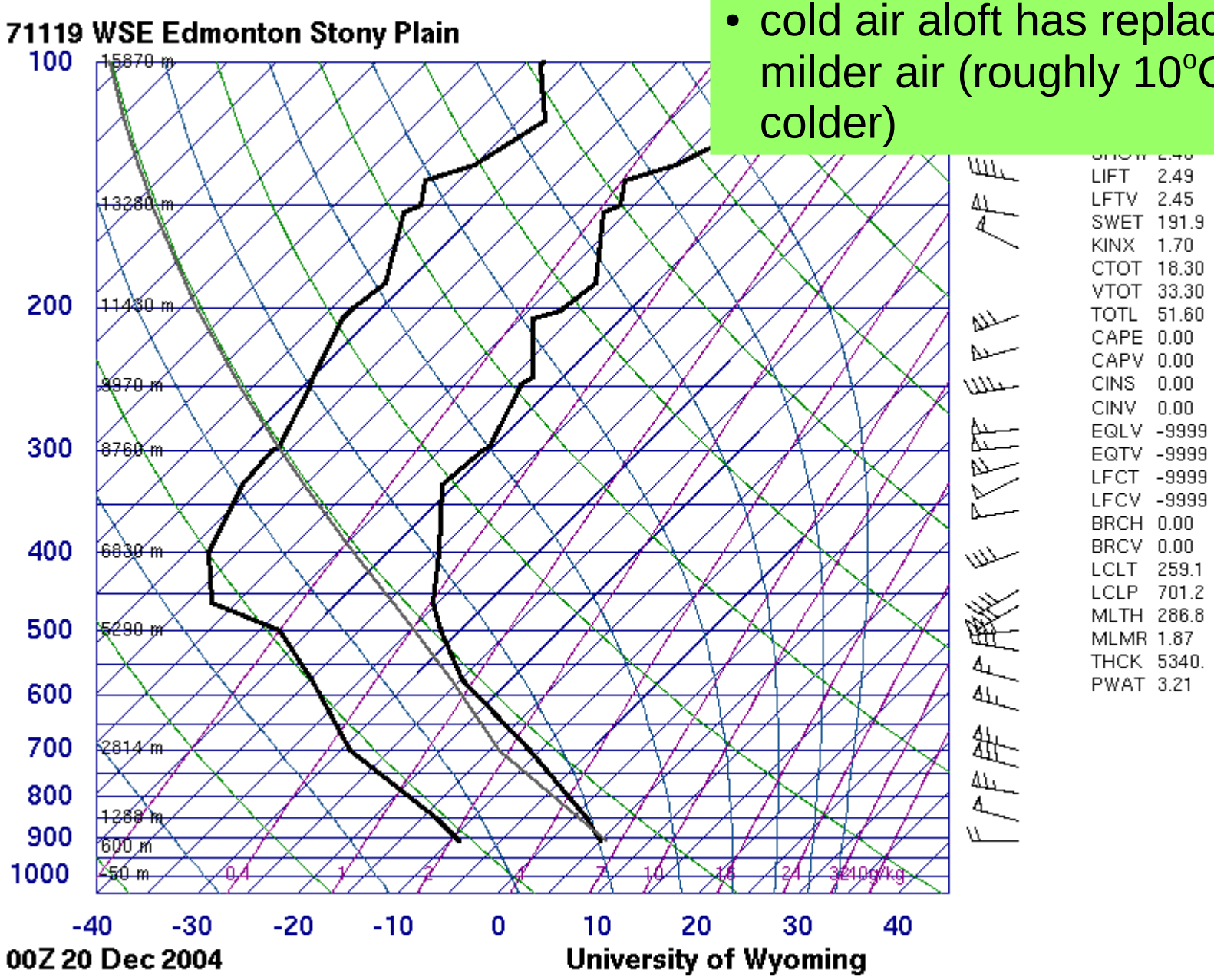


SLAT	53.53
SLON	-114.10
SELV	766.0
SHOW	5.12
LIFT	6.36
LFTV	6.33
SWET	110.9
KINX	5.10
CTOT	13.30
VTOT	30.30
TOTL	43.60
CAPE	0.00
CAPV	0.00
CINS	0.00
CINV	0.00
EQLV	-9999
EQTV	-9999
LFCT	-9999
LFCV	-9999
BRCH	0.00
BRCV	0.00
LCLT	268.3
LCLP	720.0
MLTH	294.8
MLMR	3.76
THCK	5586.
PWAT	8.97

Above the surface inversion, sounding is conditionally unstable up to ~400 hPa

Edmonton sounding after the storm: 00Z (17 MST) Dec. 20

- cold air aloft has replaced milder air (roughly 10°C colder)



71119 WSE Edmonton Stony Plain Observations at 00Z 19 Dec 2004

5 pm MST Saturday

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1000.0	159									
929.0	766	-4.1	-6.1	86	2.62	80	3	274.8	282.2	275.2
925.0	797	-4.5	-7.3	81	2.40	155	10	274.7	281.5	275.1
924.0	806	-4.7	-7.6	80	2.35	159	10	274.6	281.2	275.0
914.0	891	-4.3	-6.6	84	2.56	195	14	275.9	283.1	276.3
911.4	914	-3.4	-7.0	76	2.49	205	15	277.0	284.2	277.4
886.0	1141	6.0	-11.0	28	1.87	231	17	289.0	294.7	289.3
877.6	1219	5.8	-8.9	34	2.24	240	18	289.6	296.4	290.0
875.0	1243	5.8	-8.2	36	2.37	244	18	289.8	297.0	290.2
850.0	1480	4.8	-4.2	52	3.31	280	22	291.2	301.1	291.7

71119 WSE Edmonton Stony Plain Observations at 12Z 19 Dec 2004

5 am MST Sunday

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1000.0	4									
925.0	674									
915.0	766	4.0	-2.0	65	3.62	240	5	284.3	294.8	284.9
898.7	914	12.7	-0.6	40	4.11	245	17	294.7	307.1	295.4
897.0	929	13.6	-0.4	38	4.16	246	18	295.8	308.4	296.5
866.5	1219	13.2	-3.8	31	3.36	270	27	298.3	308.7	298.9
866.0	1224	13.2	-3.8	30	3.35	270	27	298.4	308.7	299.0
850.0	1379	11.8	-5.2	30	3.07	270	29	298.5	308.0	299.1

71119 WSE Edmonton Stony Plain Observations at 12Z 19 Dec 2004

5 am MST Sunday

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1000.0	4									
925.0	674									
915.0	766	4.0	-2.0	65	3.62	240	5	284.3	294.8	284.9
898.7	914	12.7	-0.6	40	4.11	245	17	294.7	307.1	295.4
897.0	929	13.6	-0.4	38	4.16	246	18	295.8	308.4	296.5
866.5	1219	13.2	-3.8	31	3.36	270	27	298.3	308.7	298.9
866.0	1224	13.2	-3.8	30	3.35	270	27	298.4	308.7	299.0
850.0	1379	11.8	-5.2	30	3.07	270	29	298.5	308.0	299.1

71119 WSE Edmonton Stony Plain Observations at 00Z 20 Dec 2004

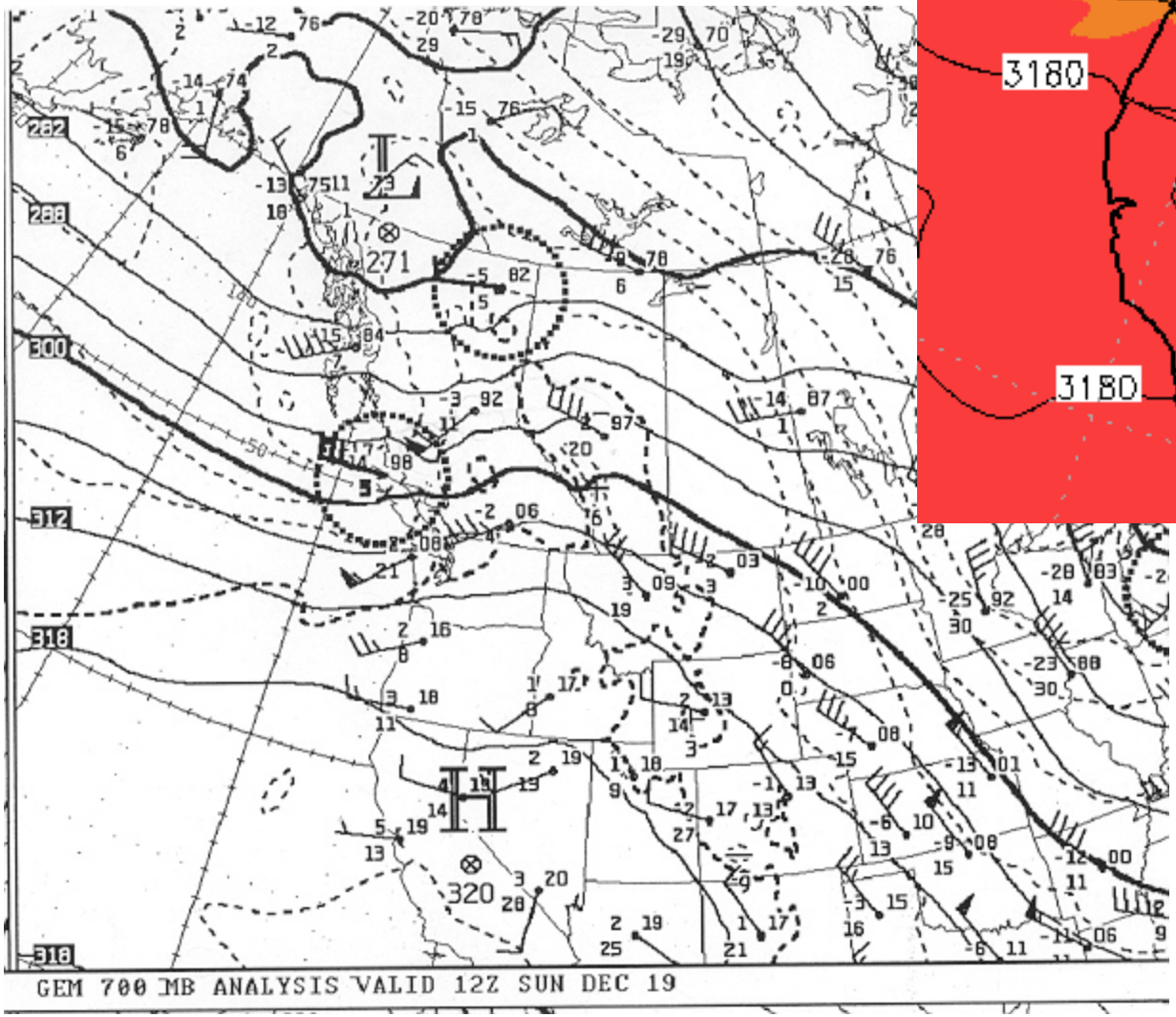
5 pm MST Sunday

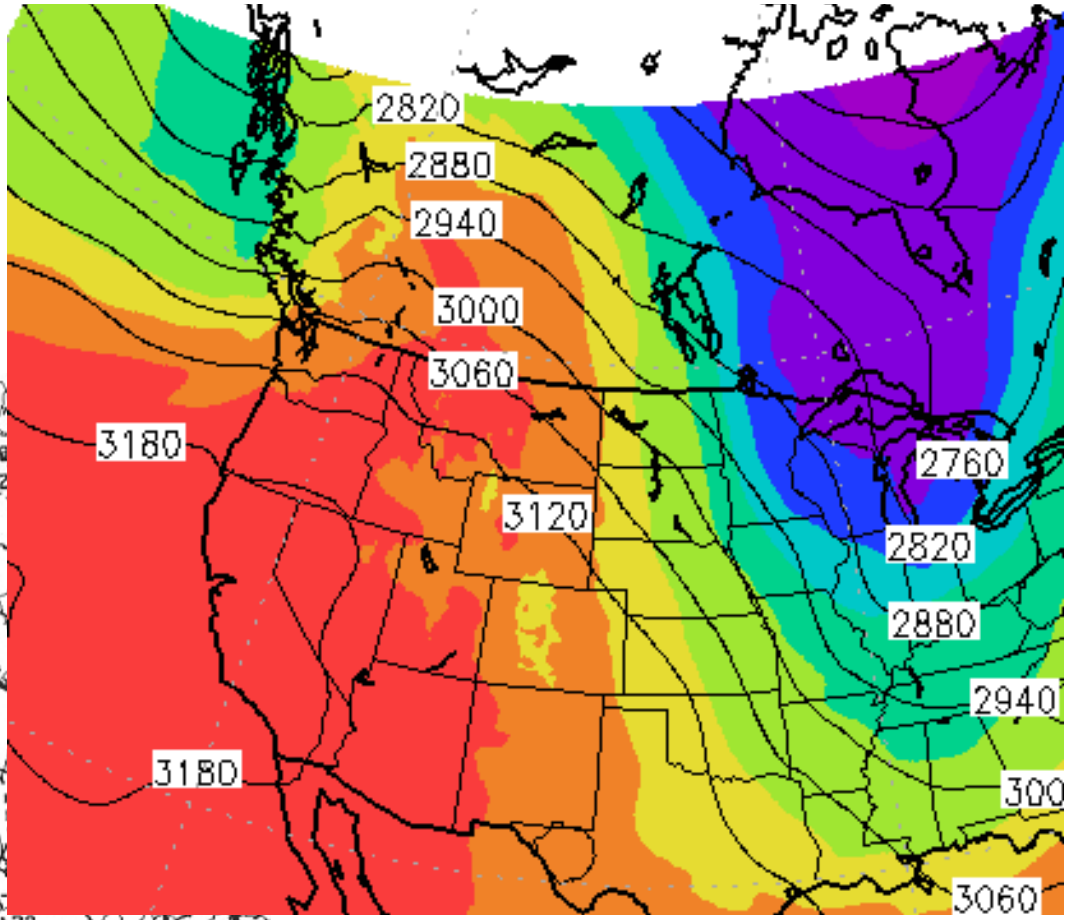
PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1000.0	-50									
925.0	600									
906.0	766	5.0	-9.0	36	2.15	270	21	286.1	292.6	286.5
889.8	914	4.0	-10.3	34	1.97	280	41	286.5	292.5	286.9
857.2	1219	1.9	-13.0	32	1.65	285	48	287.4	292.5	287.7
850.0	1288	1.4	-13.6	32	1.58	285	51	287.6	292.5	287.9

Comparing NAM analysis (http://nomads.ncdc.noaa.gov/) & original GEM

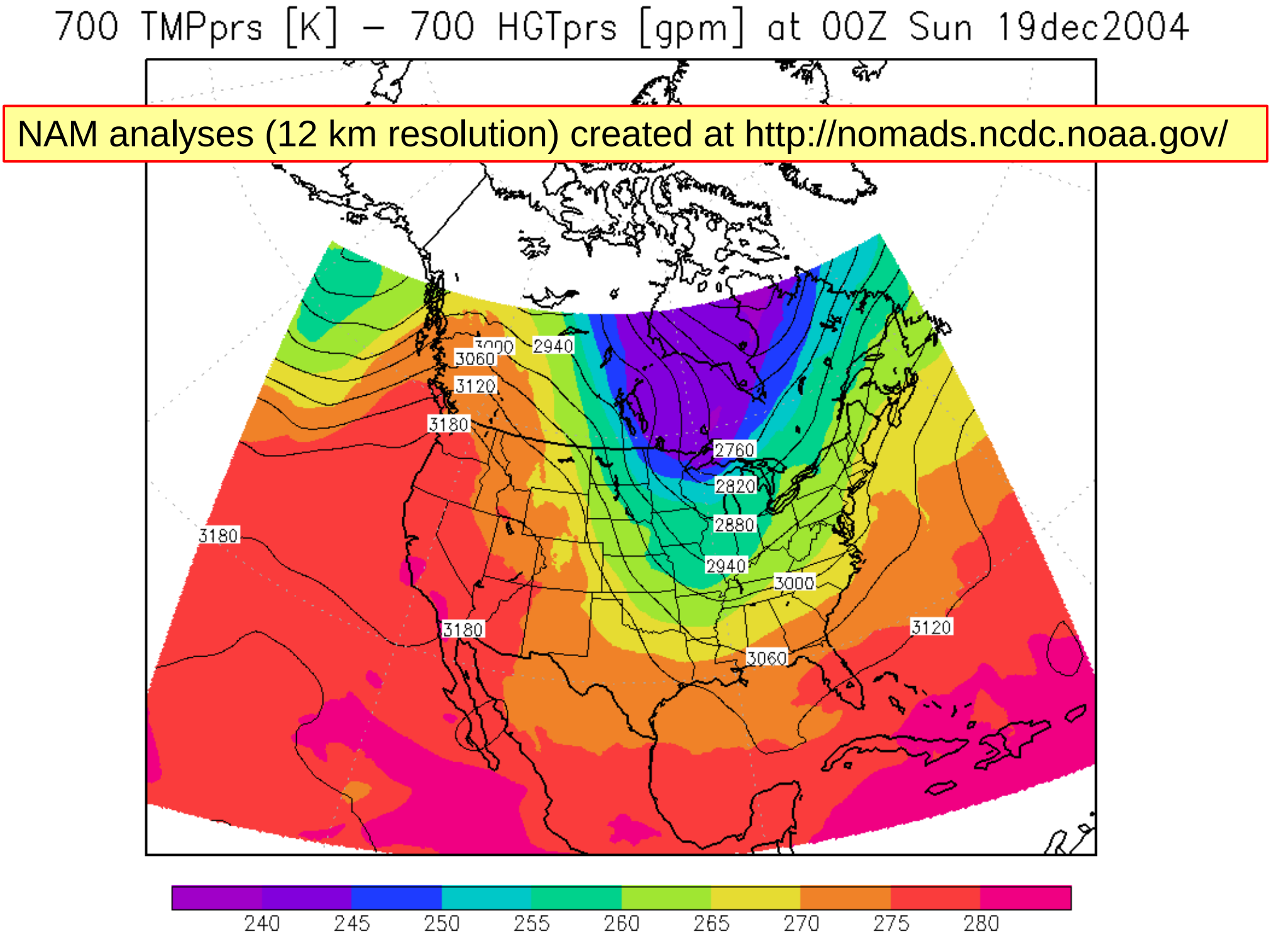
05 MST Sunday 19 Dec. 2004

(700 hPa level is ~3 km ASL)

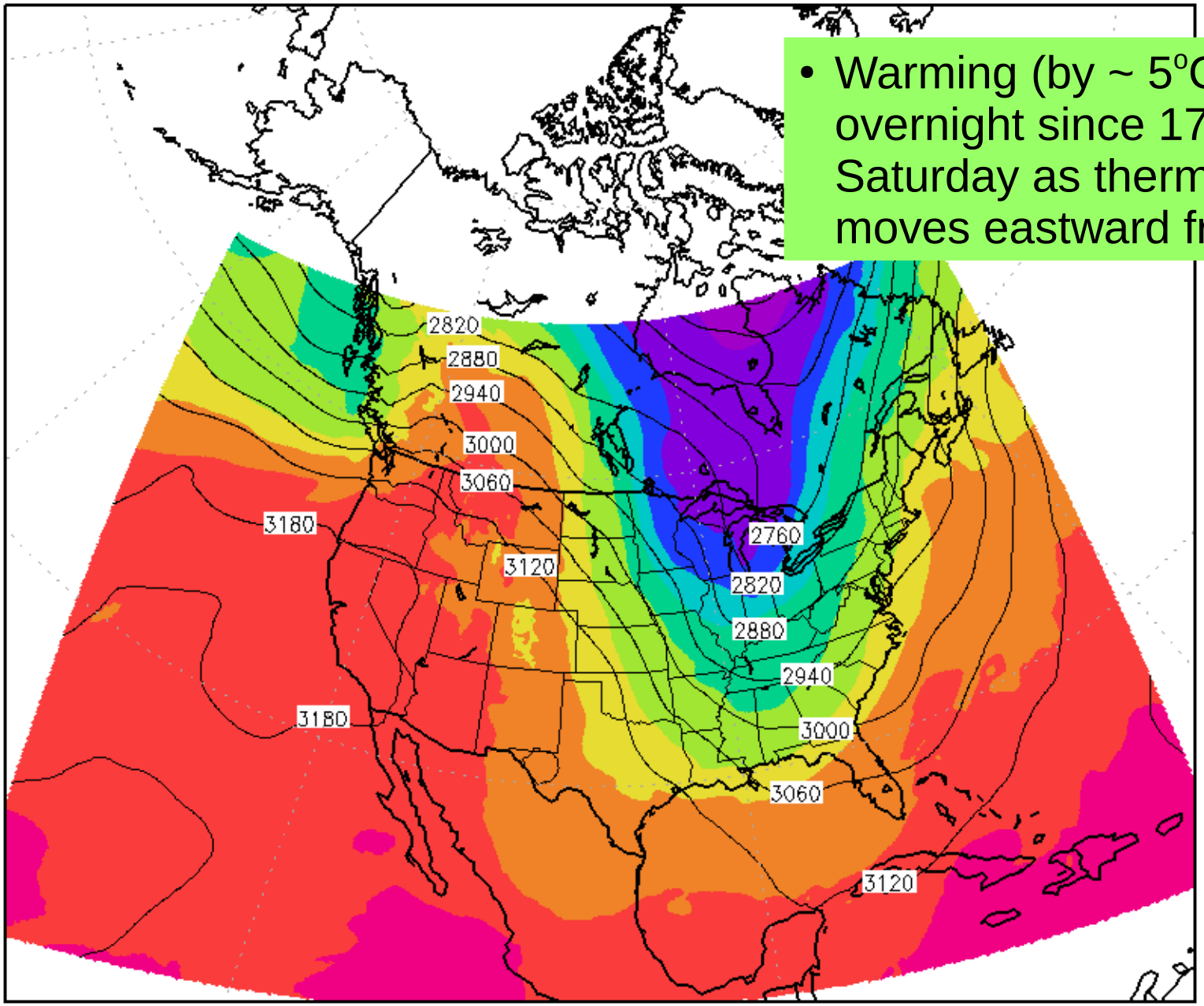




- Emphasizes the mild air over AB
- & how easily one may generate weather maps for past events

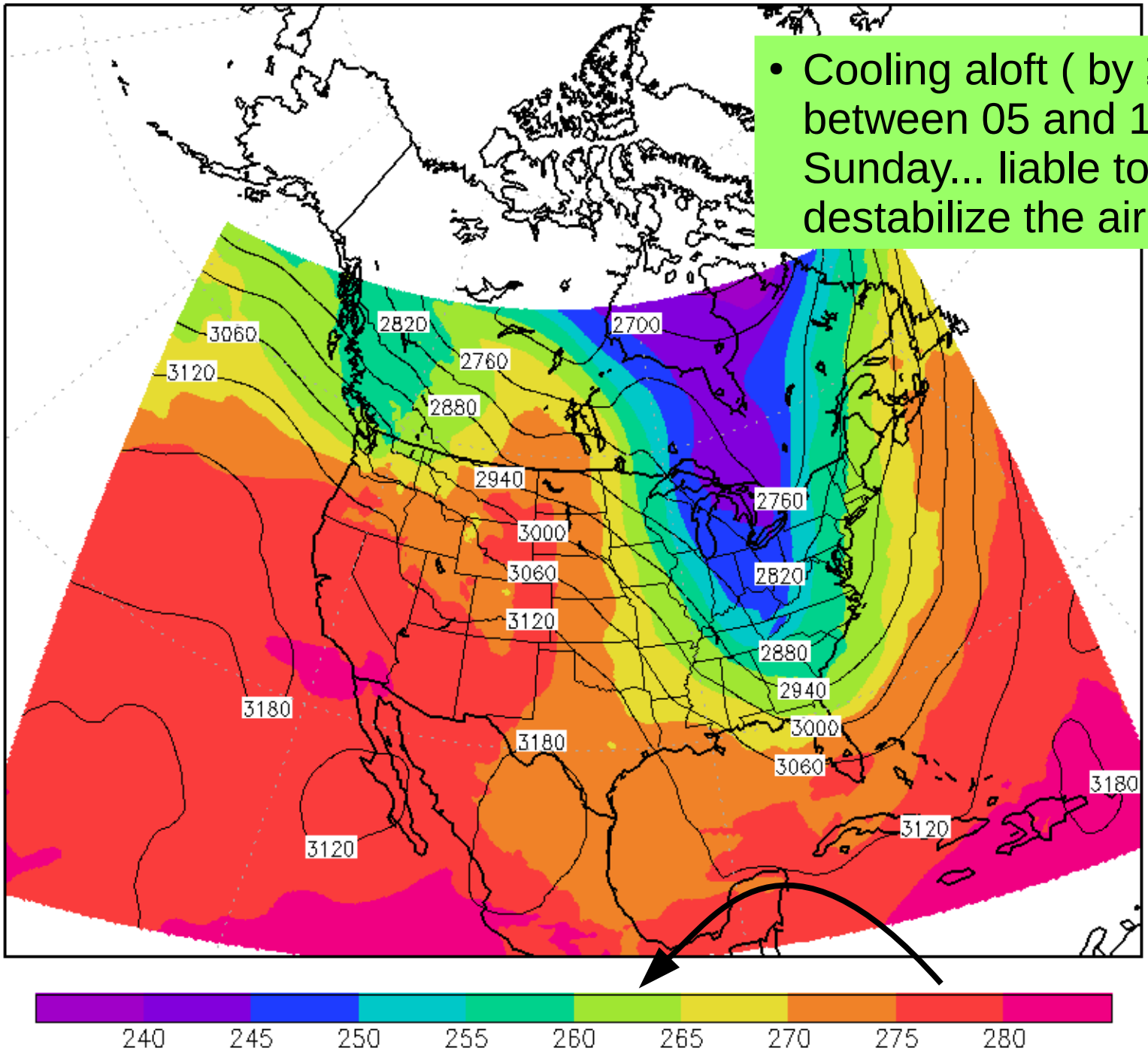

700 TMPprs [K] – 700 HGTprs [gpm] at 00Z Sun 19dec2004
NAM analyses (12 km resolution) created at http://nomads.ncdc.noaa.gov/
3000
3060
2940
3120
3180
2760
2820
2880
2940
3000
3180
3180
3120
3060
240
245
250
255
260
265
270
275
280

700 TMPprs [K] – 700 HGTprs [gpm] at 12Z Sun 19dec2004

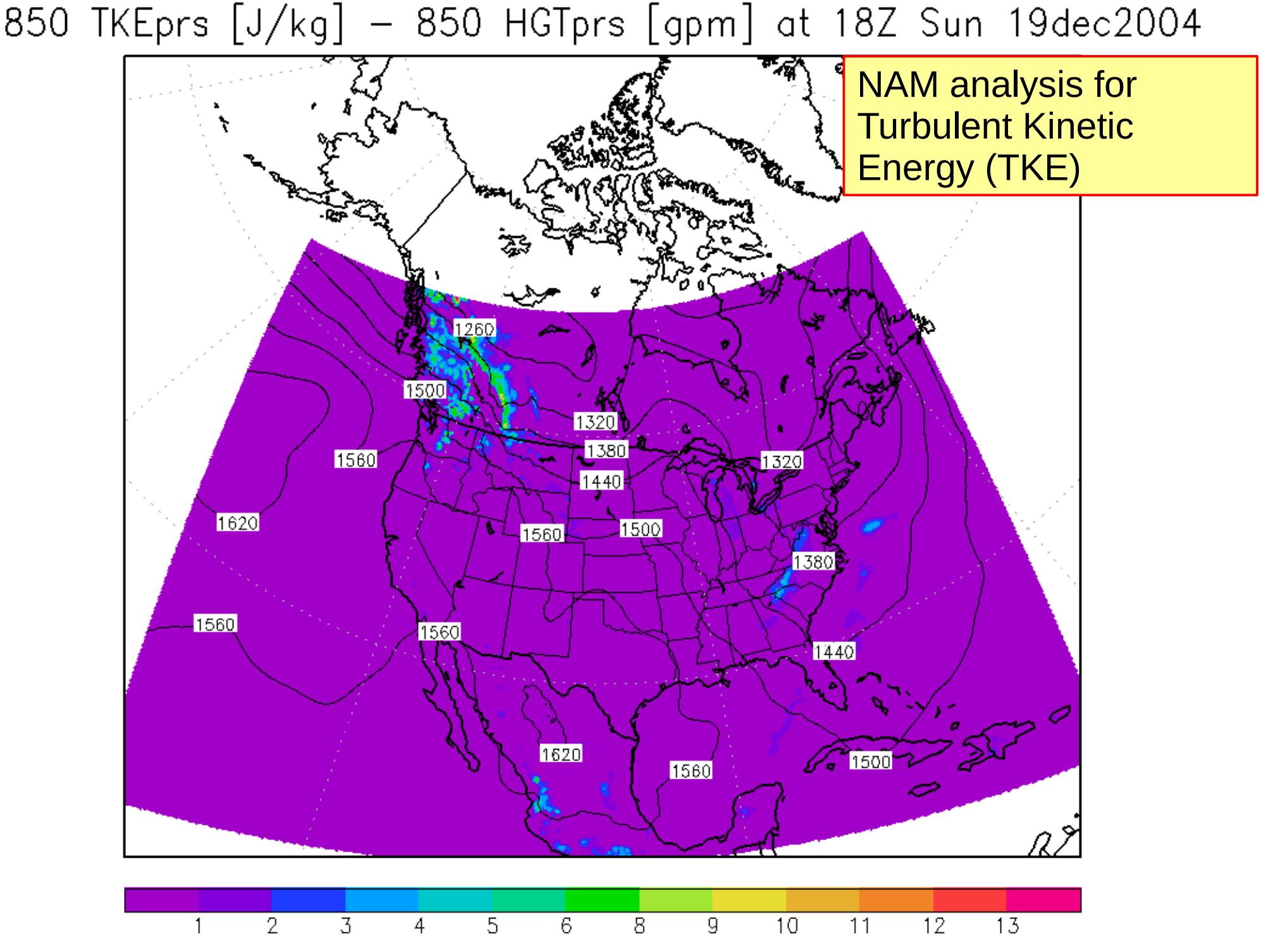


- Warming (by ~ 5°C) overnight since 17 MDT Saturday as thermal ridge moves eastward from BC

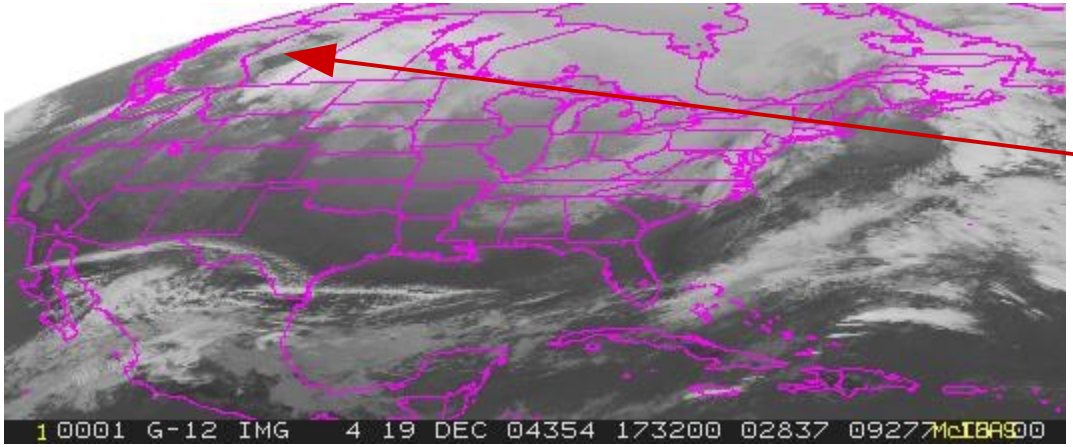
700 TMPprs [K] – 700 HGTprs [gpm] at 00Z Mon 20dec2004



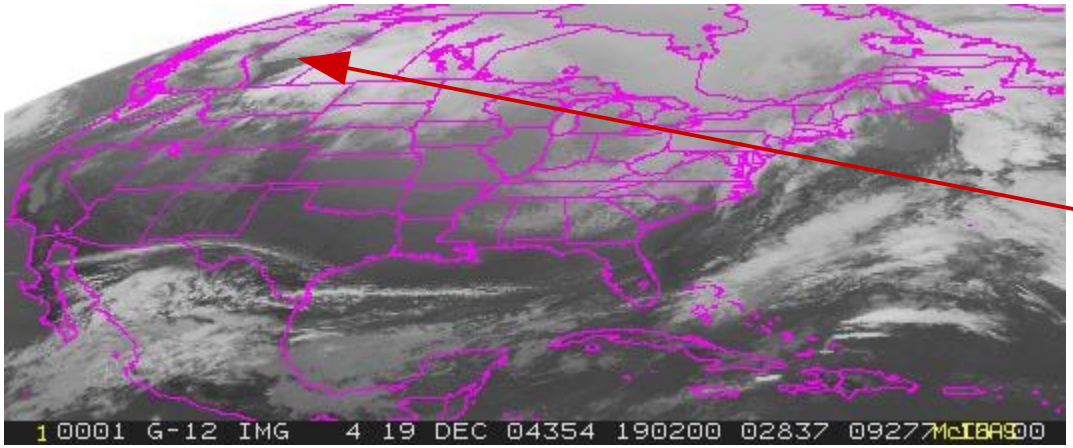
- Cooling aloft (by ≥ 10°C) between 05 and 17 MDT Sunday... liable to destabilize the air column


850 TKEprs [J/kg] – 850 HGTprs [gpm] at 18Z Sun 19dec2004
NAM analysis for Turbulent Kinetic Energy (TKE)
1260
1500
1320
1380
1560
1320
1440
1620
1560
1500
1380
1560
1560
1440
1620
1560
1500
1
2
3
4
5
6
8
9
10
11
12
13

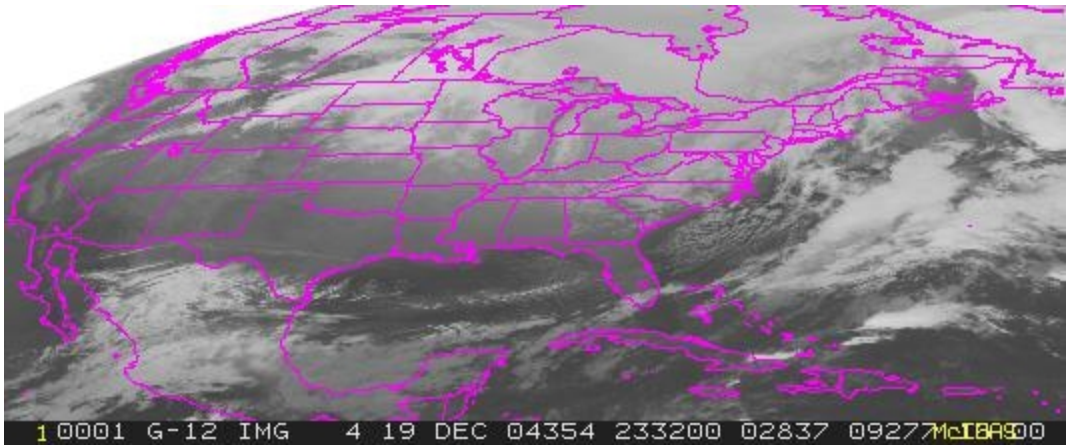
GOES East (Geostationary Orbiting Earth Satellite) 10.7 µm infrared



Sunday 10:32 am MST



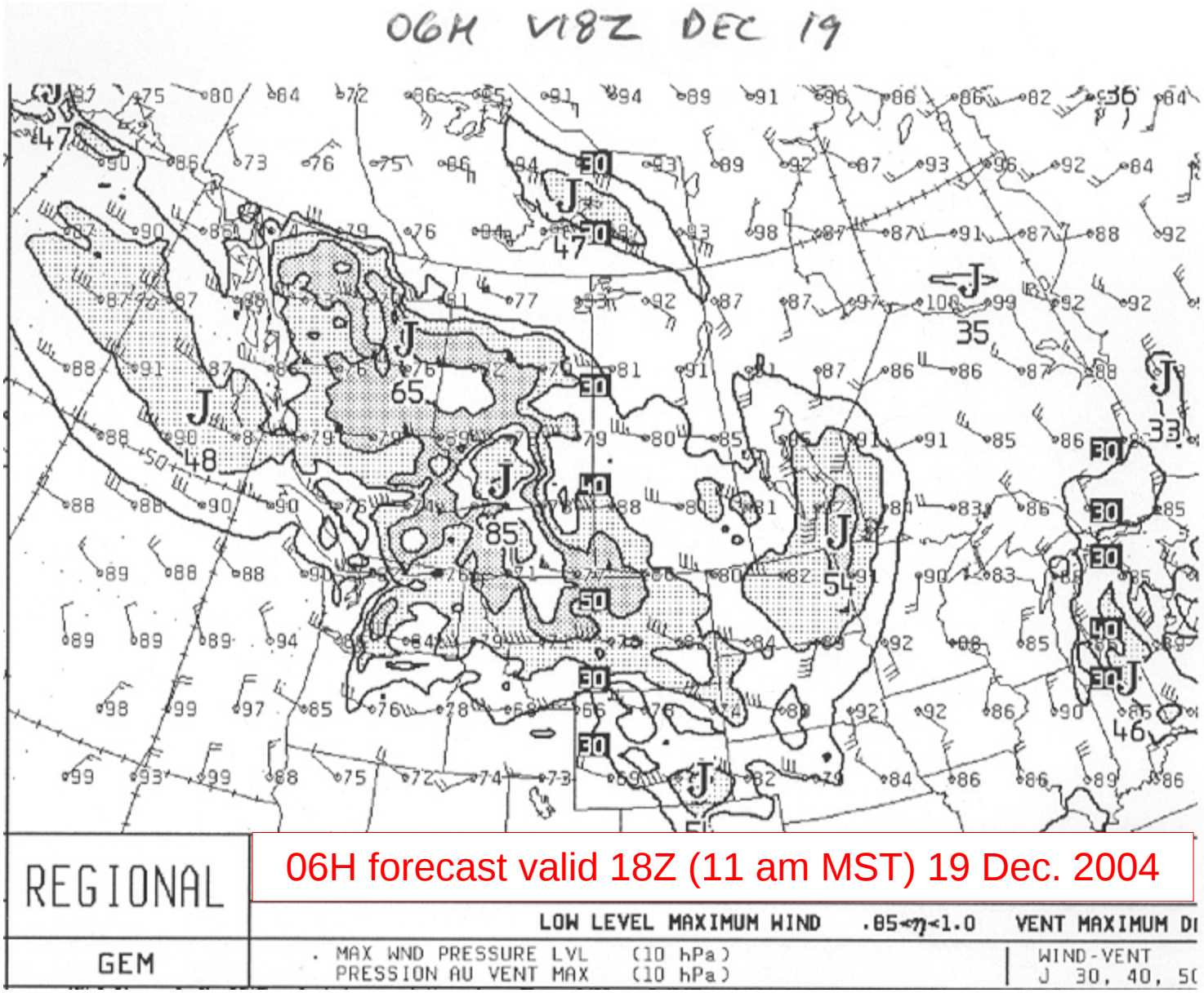
Sunday noon MST
– edge of cloud shield
visible near Edmonton



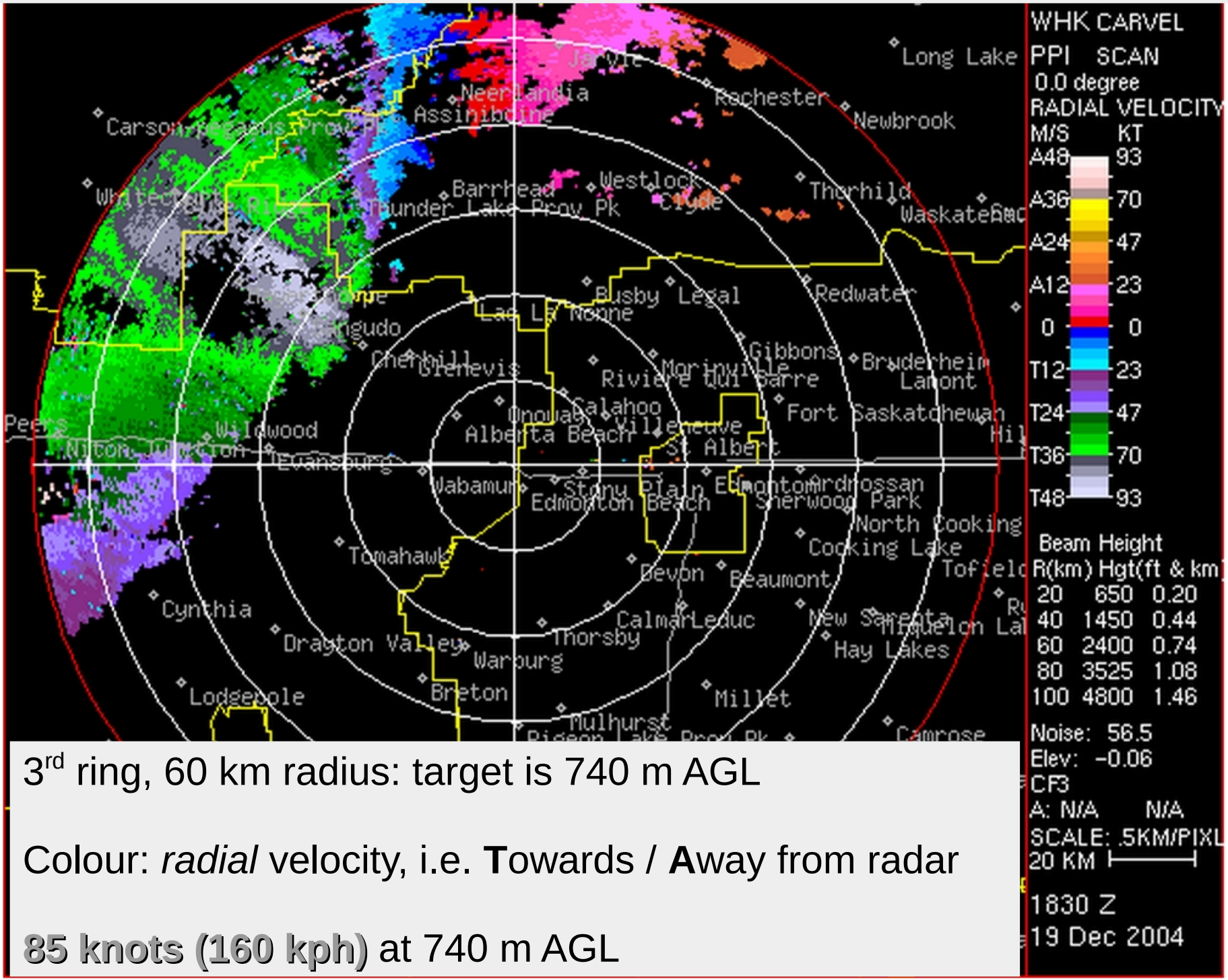
Sunday 4:32 pm MST

NWP model GEM 6hr-forecast, 85 km/hr wind maxima for 11 am MST

- The strong winds *were* forecast



Radar 11:30 MST Sun 19 Dec/04... approaching squall line

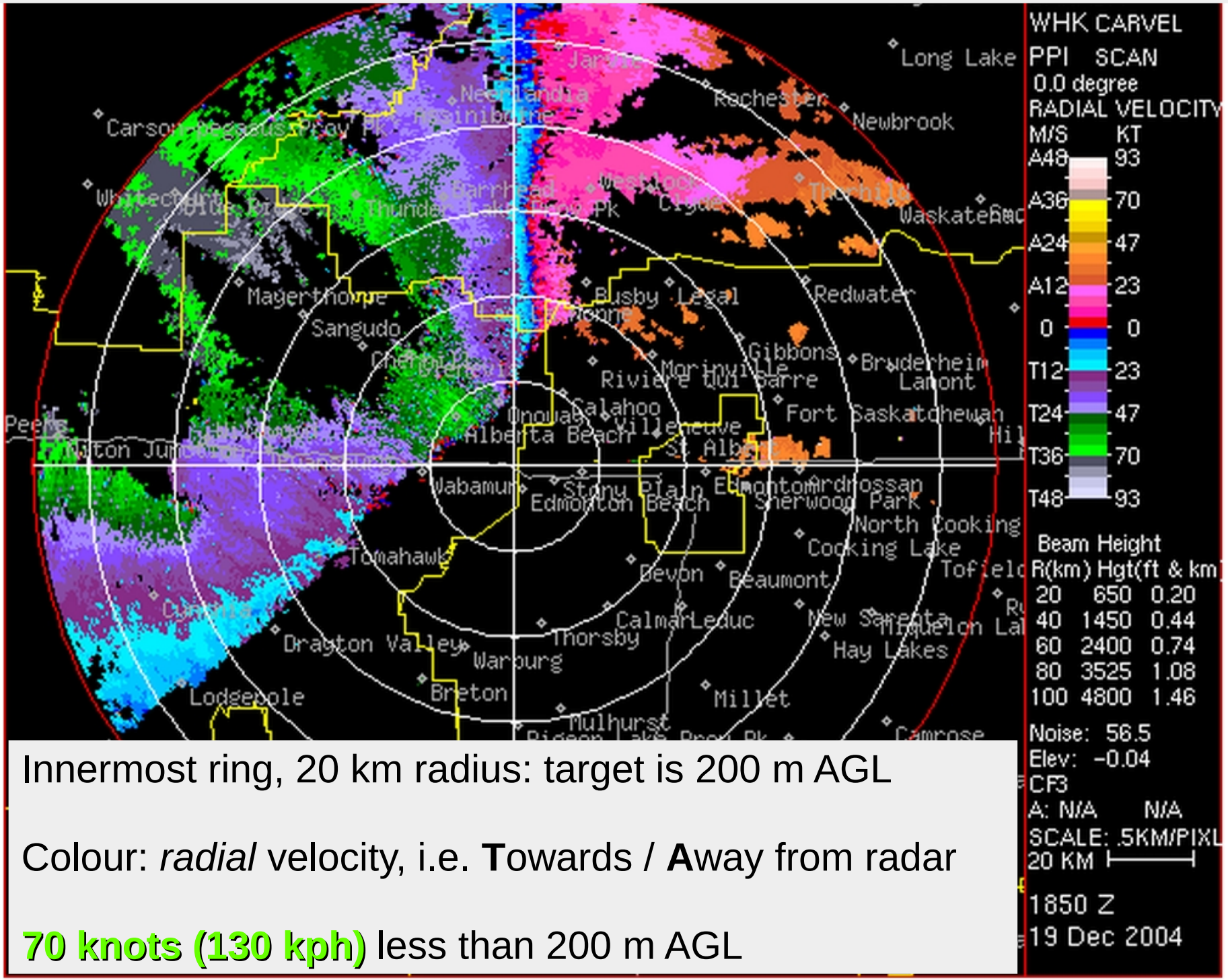


3rd ring, 60 km radius: target is 740 m AGL

Colour: *radial* velocity, i.e. **T**owards / **A**way from radar

85 knots (160 kph) at 740 m AGL

Radar 11:50 MST Sun 19 Dec/04... squall line advancing at ~ 100 km/hr



Innermost ring, 20 km radius: target is 200 m AGL

Colour: *radial* velocity, i.e. **T**owards / **A**way from radar

70 knots (130 kph) less than 200 m AGL

Summary: cause of the 19th December 2004 wind storm

- Have reviewed factors affecting surface wind; and looked at the many types of evidence that help us to comprehend extreme weather events
- Synoptic scale conditions set the scene
  - super mild air in Alberta, cold arctic air further east
  - maritime cold front advanced rapidly from BC
  - strong cold wind aloft – destabilizing the air column
  - **Environment Canada GEM model forecast the strong sfc winds**
  - rapidly moving cold front spawned a squall line
  - probably not a "sting jet", since conceptually the latter is located behind the cold front (sting jet winds occur *after* the rapid cooling)

Abbreviated Summary: Prairie and Arctic Storm Prediction Centre (PASPC)

- result of convection bringing strong winds aloft to the surface along a line of showers or thunderstorms
- wintertime convection, although weak by summer standards, may produce severe wind gusts since winds aloft are usually much stronger
- even weak convection in the cold season may mix potentially damaging winds to the surface, especially in a cold advection unstable situation
- an unseasonably mild airmass over Alberta was being replaced by cooler air from BC with sharply falling temperatures aloft
- the leading edge of this cooler airmass was marked by a cold front that triggered thunderstorms, a signal of strong instability
- though the convection "weakened" within a couple of hours... the squall line along the cold front continued to produce extreme wind gusts due to very strong winds aloft