Goals for today:

26 Sept., 2011

- The weekend's warm weather in Edmonton –
  - first look at a thermodynamic chart (the Stuve diagram)
  - the 850 hPa temperature field – strong temperature contrast between central and far northern Ab
- Continue Ch 3 “Energy Balance & Temperature”
  - the nocturnal radiation inversion
  - diurnal range in temperature
  - the turbulent “friction layer” (atmospheric boundary layer)
  - Earth's radiative equilibrium temperature

Edmonton City Centre Airport
Past 24 Hour Conditions

Imperial Units

Date / Time (MDT)	Conditions	Temp (°C)	Humidity (%)	Dew Point (°C)	Wind (km/h)
25 September 2011					
17:00	Sunny	23	39	8	NW 13
16:00	Light Rain	24	35	8	WNW 22 gust 37
15:00	Sunny	32	16	3	SSW 33
14:00	Sunny	30	20	5	SSE 26 gust 37
13:00	Sunny	29	20	4	SSE 32 gust 45
12:00	Sunny	27	22	4	SSE 30
11:00	Sunny	26	25	4	SSE 24
10:00	Sunny	22	29	3	SSE 18
9:00	Sunny	20	32	2	S 18 gust 30
8:00	Sunny	15	41	2	SSE 8
7:00	Clear	14	42	1	SSE 4
6:00	Clear	14	44	2	SE 11
5:00	Clear	16	38	2	SSE 15
4:00	Clear	16	41	2	ESE 8
3:00	Clear	18	38	3	SE 13
2:00	Clear	18	45	6	SE 18
1:00	Clear	17	54	8	SE 13
00:00	Clear	13	76	9	calm
24 September 2011					
23:00	Clear	16	66	9	NE 5
22:00	Clear	16	62	9	ENE 9
21:00	Clear	18	57	9	NE 9
20:00	Clear	17	56	8	NE 11
19:00	Sunny	22	45	9	NE 15
18:00	Sunny	23	41	9	NE 17
17:00	Sunny	24	41	10	NE 9

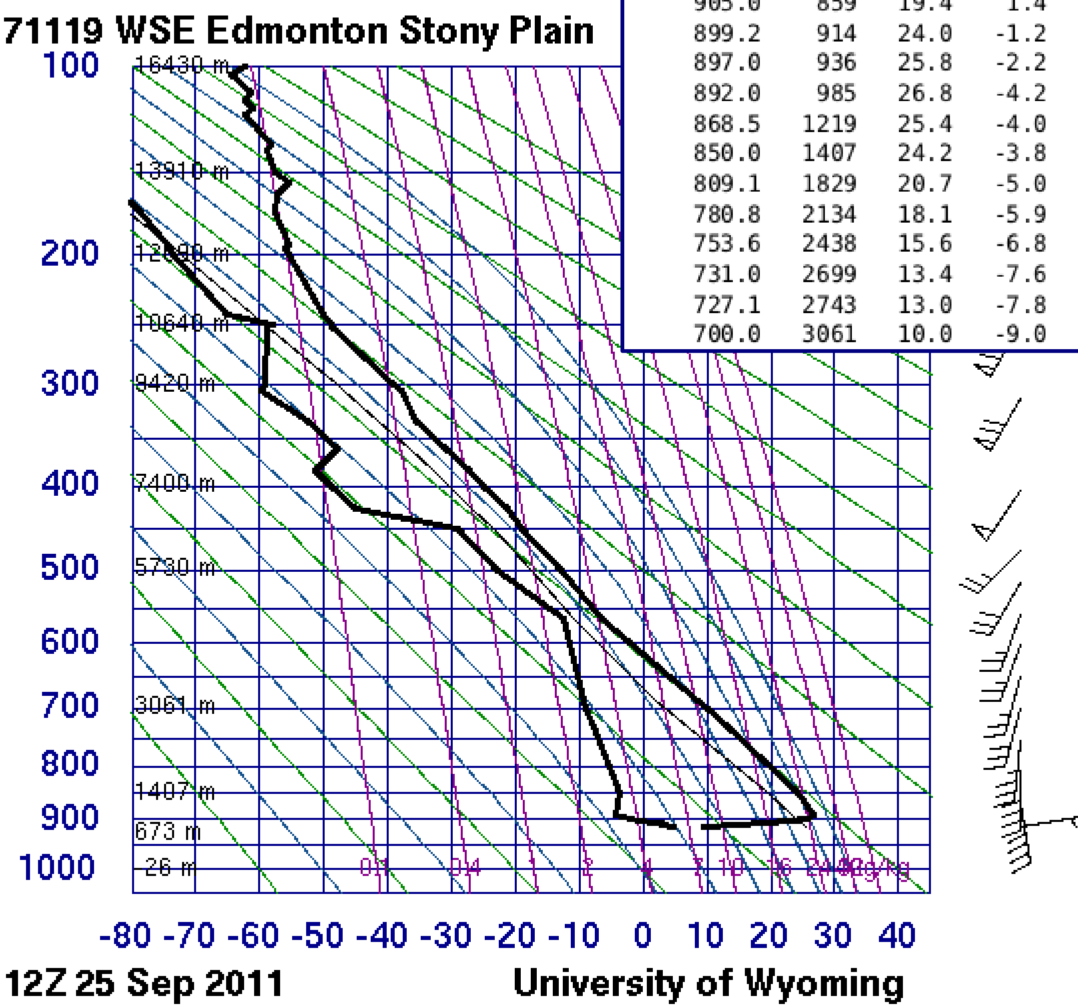
Historical Data

Yesterday		Normals	
Max:	**24.1°C**	Max:	**15°C**
Min:	**7.2°C**	Min:	**2°C**

Saturday 24 Sept

71119 WSE Edmonton Stony Plain Observations at 12Z 25 Sep 2011

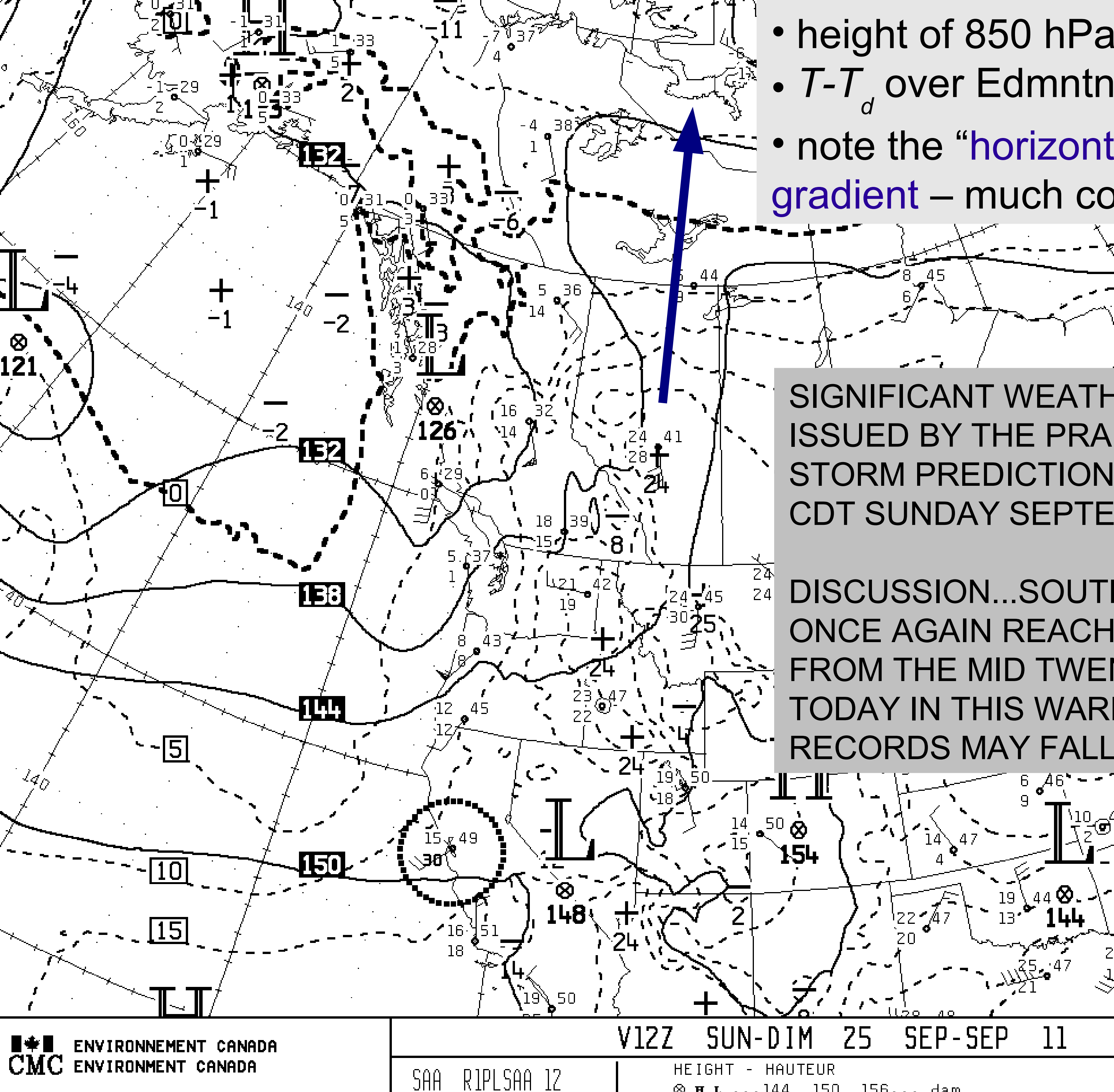
PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1000.0	-26									
925.0	673									
915.0	766	9.6	4.8	72	5.93	80	5	290.0	307.2	291.1
909.0	821	14.8	2.8	44	5.18	114	18	295.9	311.4	296.8
906.0	849	19.0	3.0	35	5.27	131	24	300.5	316.5	301.5
905.0	859	19.4	1.4	30	4.70	137	27	301.0	315.4	301.9
899.2	914	24.0	-1.2	19	3.92	170	39	306.3	318.7	307.0
897.0	936	25.8	-2.2	16	3.64	170	39	308.4	320.1	309.1
892.0	985	26.8	-4.2	13	3.15	170	39	309.9	320.2	310.5
868.5	1219	25.4	-4.0	14	3.29	170	40	310.8	321.5	311.4
850.0	1407	24.2	-3.8	15	3.41	170	42	311.5	322.6	312.1
809.1	1829	20.7	-5.0	17	3.26	180	38	312.1	322.8	312.8
780.8	2134	18.1	-5.9	19	3.16	185	40	312.6	323.0	313.2
753.6	2438	15.6	-6.8	21	3.05	185	34	313.0	323.1	313.6
731.0	2699	13.4	-7.6	23	2.97	189	31	313.4	323.2	313.9
727.1	2743	13.0	-7.8	23	2.94	190	31	313.4	323.1	314.0
700.0	3061	10.0	-9.0	25	2.78	195	28	313.5	322.7	314.1



Stuve diagram (pp90-91) for Sunday morning

- note the ground-based nocturnal inversion layer
- wind southerly to about 800 hPa
- large $T-T_d$ (temp-dewpoint spread) above the inversion

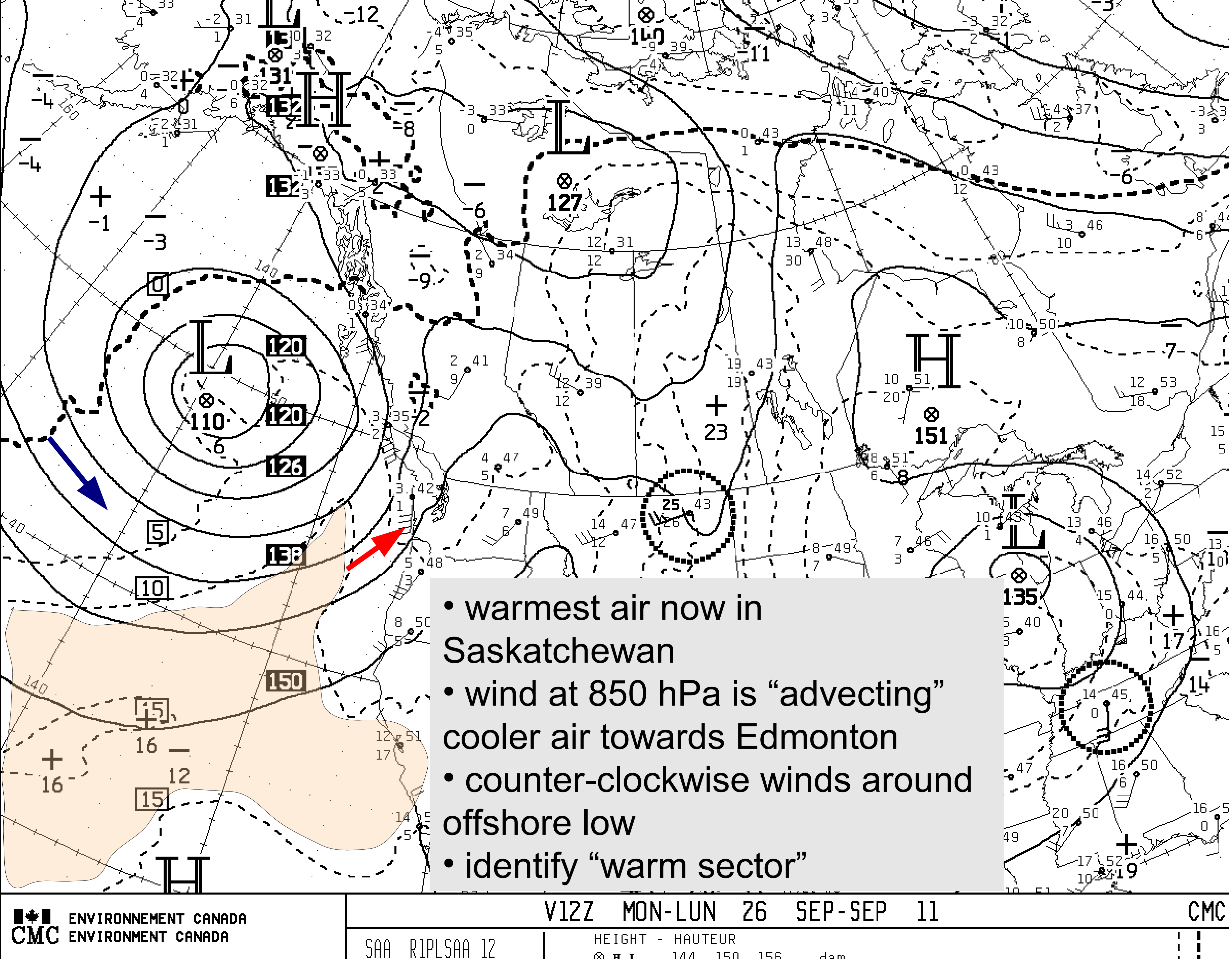
- height of 850 hPa sfc over Edmntn?
- $T - T_d$ over Edmntn?
- note the “horizontal” temperature gradient – much colder air in NWT



= 06 MDT

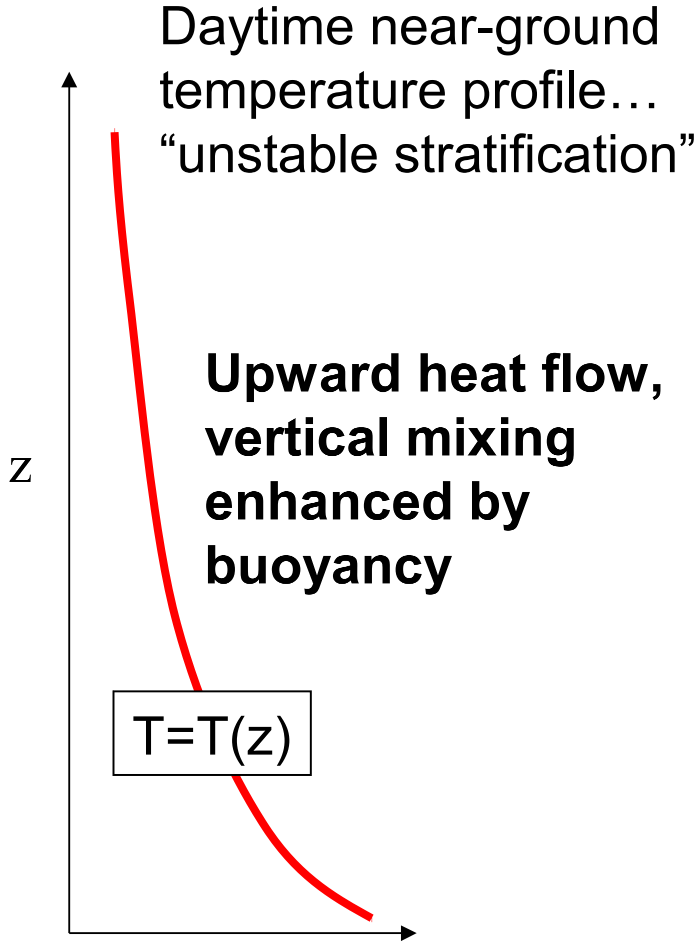
SIGNIFICANT WEATHER DISCUSSION ISSUED BY THE PRAIRIE AND ARCTIC STORM PREDICTION CENTRE AT 7:00 AM CDT SUNDAY SEPTEMBER 25 2011.

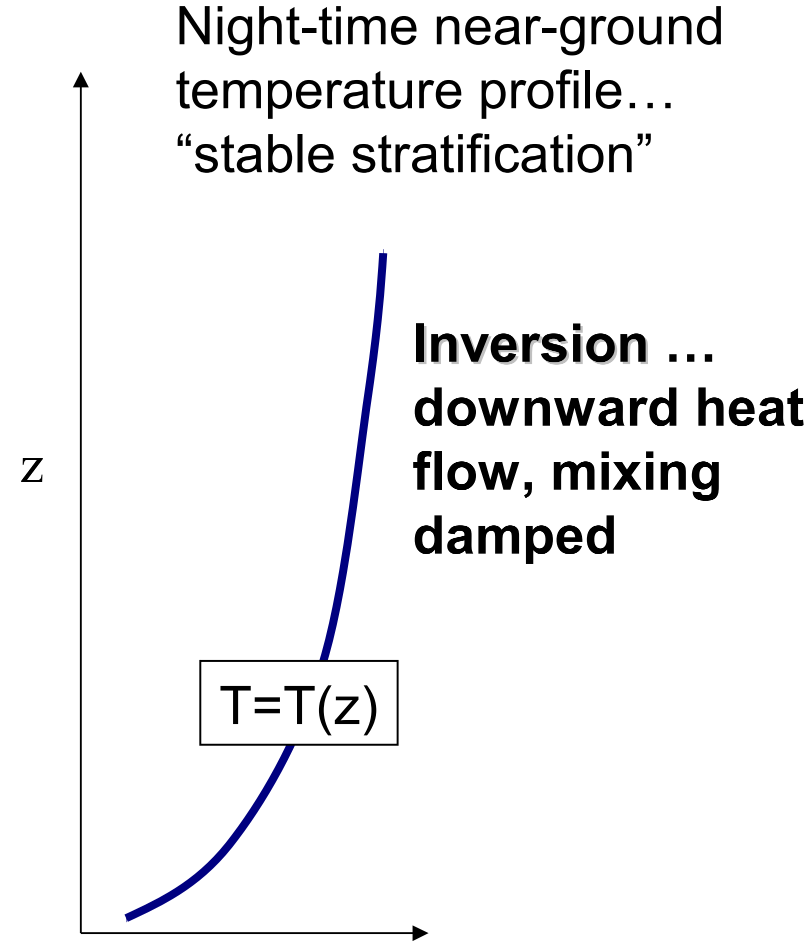
DISCUSSION...SOUTHERN PRAIRIES WILL ONCE AGAIN REACH TEMPERATURES FROM THE MID TWENTIES TO NEAR 30 C TODAY IN THIS WARM AIRMASS... RECORDS MAY FALL



- warmest air now in Saskatchewan
- wind at 850 hPa is “advecting” cooler air towards Edmonton
- counter-clockwise winds around offshore low
- identify “warm sector”

Diurnal cycle in near-ground stratification





Recall the notation T=T(z) means "T varies with z" or "T is a function of z"

Nocturnal Radiation Inversion

Cause …

- ground cooling: $Q^* < 0$, ie. outgoing longwave radiation exceeds incoming longwave

- then air above cools by convection (stirring), $Q_H < 0$

Conditions for severest inversion …

- clear sky, dry air

- long night with light wind

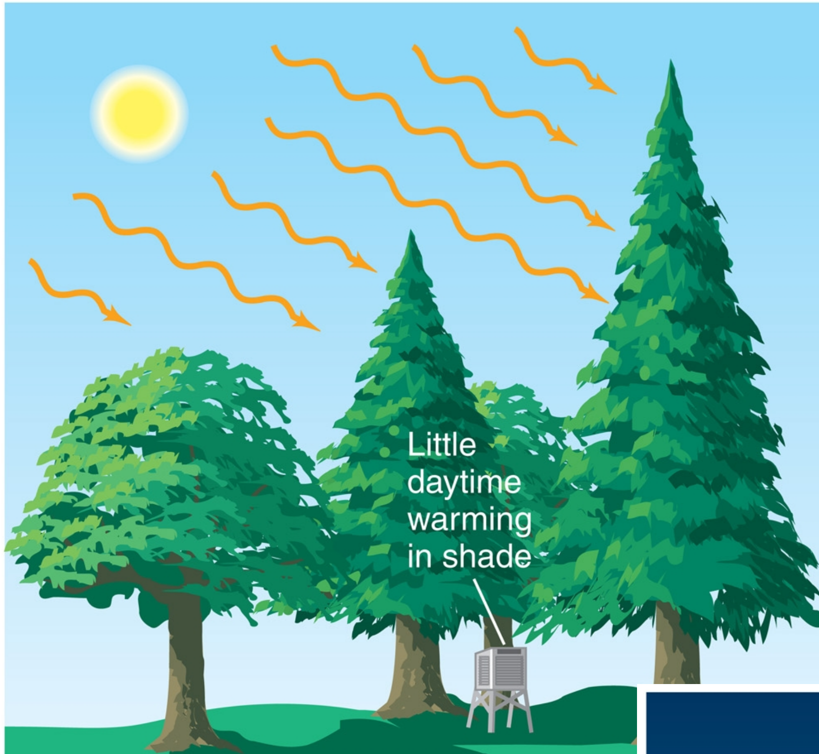
Result... radiation frost?

Photo :Keith Cooley

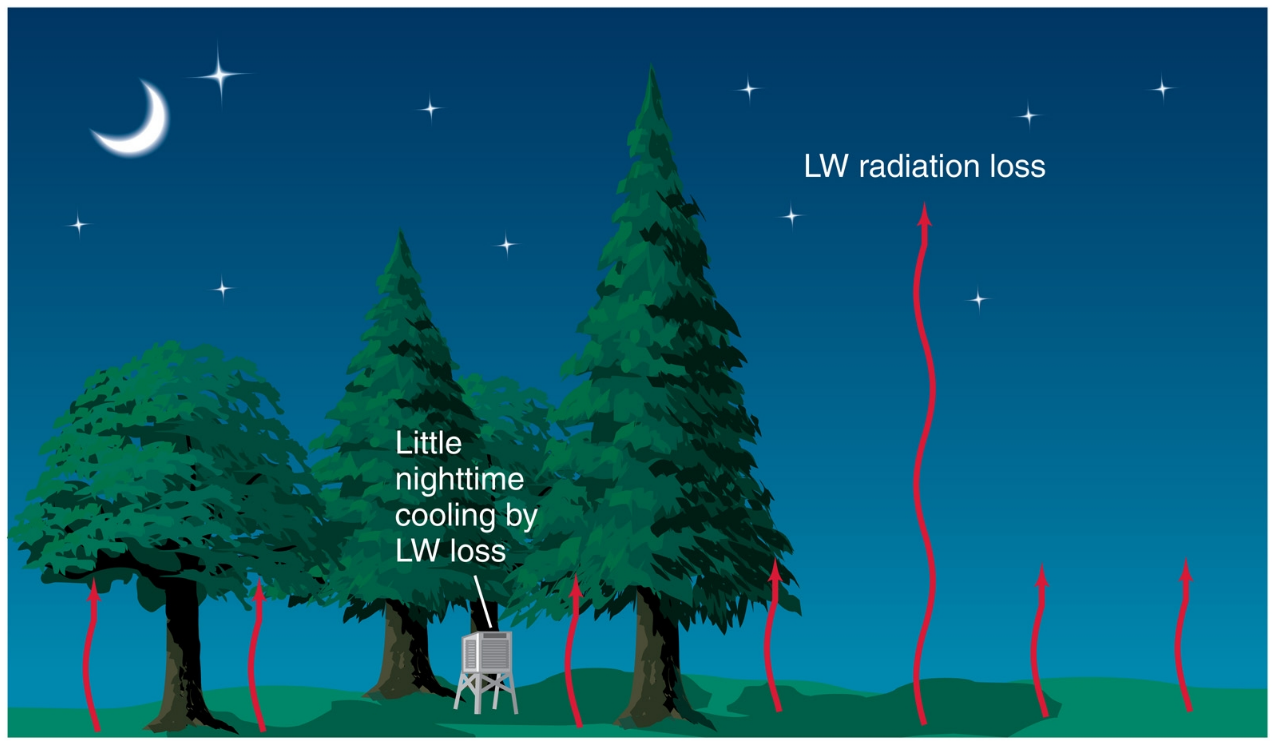
Figs. 3-22

We've been focused on the energy fluxes to/from ground, and their influence on the local daily cycle in temperature...

“Amplitude of the daily temperature pattern is (also) reduced under overcast conditions” and during windy conditions



Local (site-specific) effects on local radiation and energy balance produce “micro-climates” that can be manipulated (e.g. windbreaks)



The atmospheric boundary layer (ABL) and the depth (δ) of mixing

"free troposphere"

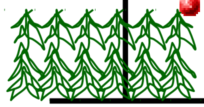
- no friction
- vertical velocities rather steady and of order cm s^{-1} except in clouds/over mountains

δ -

"friction layer" or "boundary layer"

- nominally δ ~ 1 – 3 km (summer afternoon maximum), but δ << 1 km winter morning
- friction reduces windspeed and results in a cross-isobar wind component (towards low pressure)
- variation of wind with height; daytime instability (warm air underneath cold) and flow around obstacles produce turbulence; nocturnal stability suppresses mixing
- vertical velocities fluctuate and are of order m s^{-1}

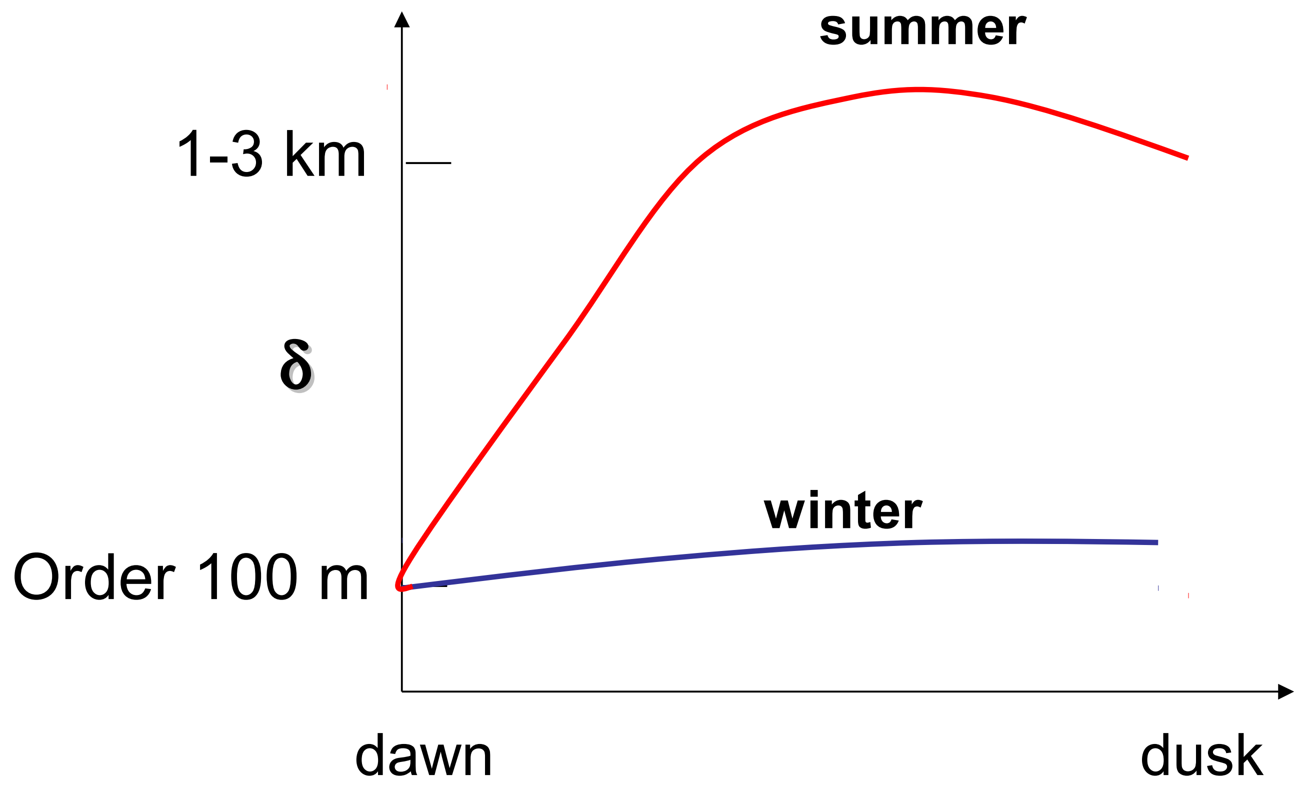
z



Depth (δ) of mixing varies in time/space

Depth of the ABL (i.e. magnitude of δ) depends on the turbulence, and increases with:

- stronger surface heating Q_H
- stronger wind
- rougher surface



Why might we consider earth's global climatological temperature T_{eq} to be at equilibrium (Sec. 3-2)?

Because there is a stabilizing feedback. Let ΔT_{eq} be the change in T_{eq} over time interval Δt . Then,

area of earth's shadow

area of earth's surface

$$\frac{\Delta T_{eq}}{\Delta t} \propto \pi R^2 (1-a) S_0 - 4\pi R^2 \epsilon \sigma T_{eq}^4$$

Rate of change $\propto$	gains	minus	losses

R is earth's radius, S_0 is the solar constant, *a* (=0.3) is the planetary albedo, ε (≈1) is the planetary emissivity and σ is the Stefan-Boltzmann constant. The proportionality constant involves the heat capacity of the earth-atmosphere system. (In reality *a*,ε may depend on T_{eq}).

At earth's (hypothetical) equilibrium temperature, there is balance:

Both sides of the equation are zero, thus setting the right hand side to zero

$$C \frac{\Delta T_{eq}}{\Delta t} = 0 \propto \pi R^2 (1-a) S_0 - 4\pi R^2 \epsilon \sigma T_{eq}^4$$

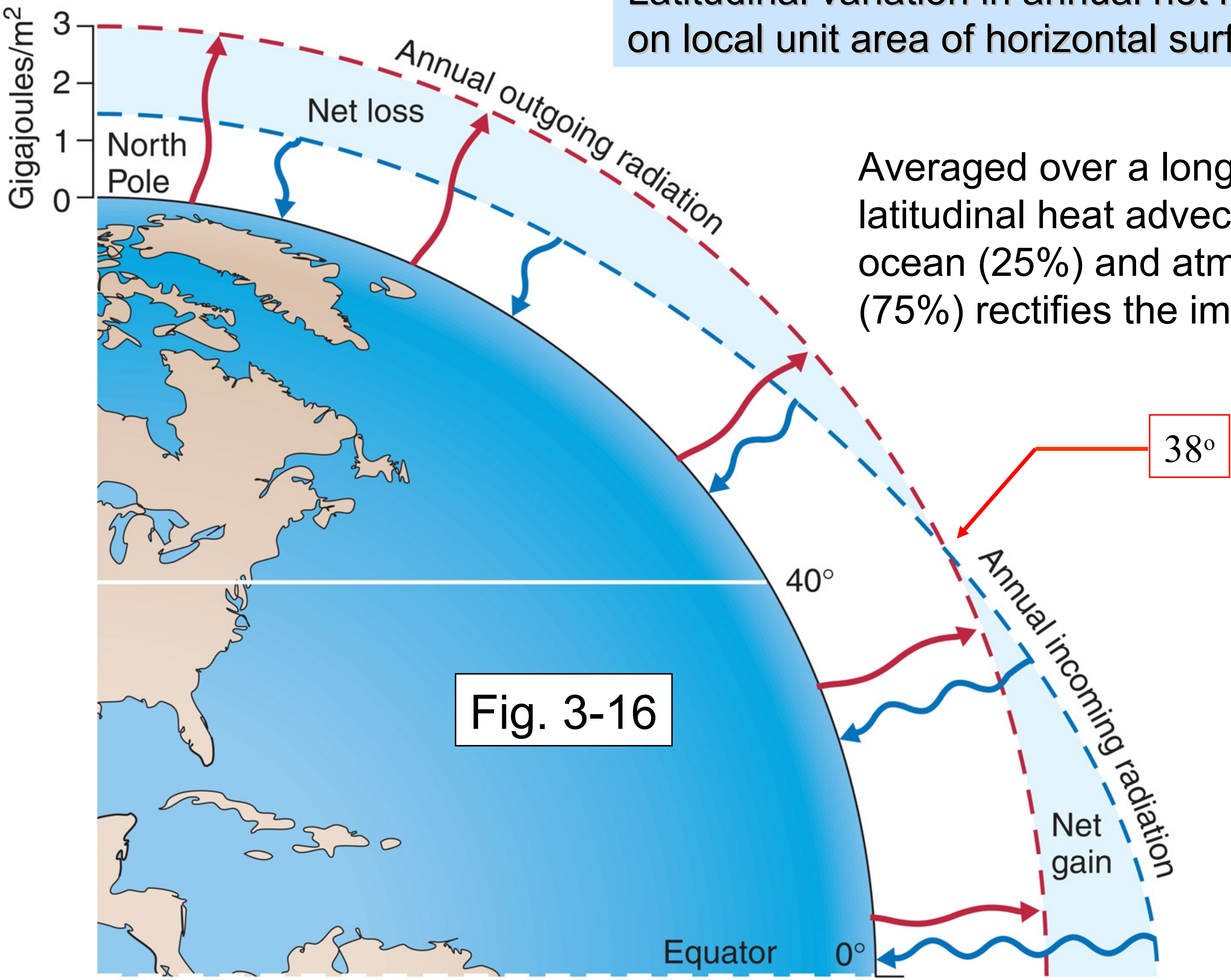
Common factors cancel

Set a =0.3 and ε=*1* to obtain earth's (radiative) equilibrium temperature (Sec. 3-2),

T_{eq} = 255 K

(However this entirely neglects the effect of the atmosphere – true global-annual mean surface temperature is about 288 K)

Latitudinal variation in annual net radiation on local unit area of horizontal surface



Averaged over a long period, latitudinal heat advection by ocean (25%) and atmosphere (75%) rectifies the imbalance

Fig. 3-16