EAS270_Ch7_WaterVapour_B.odp
JDW, EAS U.Alberta, last mod. 18 Oct. 2016

TABLE 7.1 | Saturation vapour pressure at different air temperatures, or vapour pressure at different dew-point temperatures,[a] over flat surfaces of pure liquid water or ice.[b]

Please attempt to answer these questions

over water (ice)

Air Temperature/Dew-Point Temperature (°C)	Saturation Vapour Pressure/Vapour Pressure (kPa)	Air Temperature/Dew-Point Temperature (°C)	Saturation Vapour Pressure/Vapour Pressure (kPa)
–14	0.181 (0.208)	0	0.611
–13	0.198 (0.225)	1	0.657
–12	0.217 (0.244)	2	0.705
–11	0.238 (0.264)	3	0.758
–10	0.260 (0.286)	4	0.813
–9	0.284 (0.310)	5	0.872
–8	0.310 (0.335)	6	0.935
–7	0.338 (0.362)	7	1.001
–6	0.369 (0.391)	8	1.072
–5	0.402 (0.421)	9	1.147
–4	0.437 (0.455)	10	1.227
–3	0.476 (0.490)	11	1.312
–2	0.517 (0.528)	12	1.401
–1	0.562 (0.568)	13	1.497
0	0.611 (0.611)	14	1.598
		15	1.704

If T=10, what is the equilib.v.p.?

If T_d=10, what is the v.p.?

If T=10, what is the v.p.?

If T_d=10, what is the equilib.v.p.?

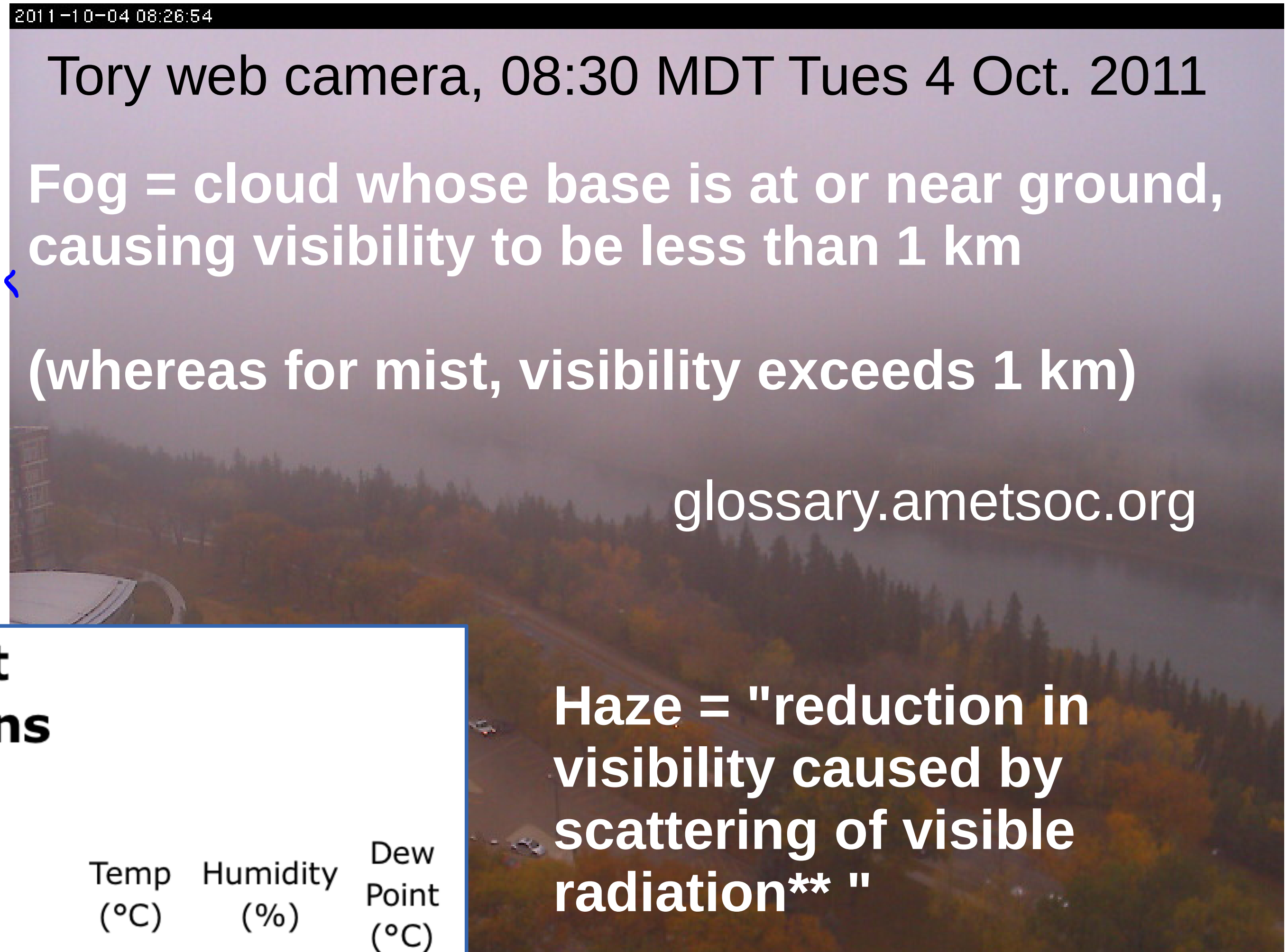
If e=13.12 hPa, what is T_d?

If e*=13.12 hPa, what is T_d?

If e*=13.12 hPa, what is T?

What does it mean to say air is "supersaturated"?

Vapour pressure e exceeds the benchmark $e_*(T)$. But the benchmark is defined in relation to a very different system.



Tory web camera, 08:30 MDT Tues 4 Oct. 2011

Fog = cloud whose base is at or near ground, causing visibility to be less than 1 km

(whereas for mist, visibility exceeds 1 km)

glossary.ametsoc.org

Haze = "reduction in visibility caused by scattering of visible radiation "**

Edmonton Int'l Airport Past 24 Hour Conditions

Imperial Units

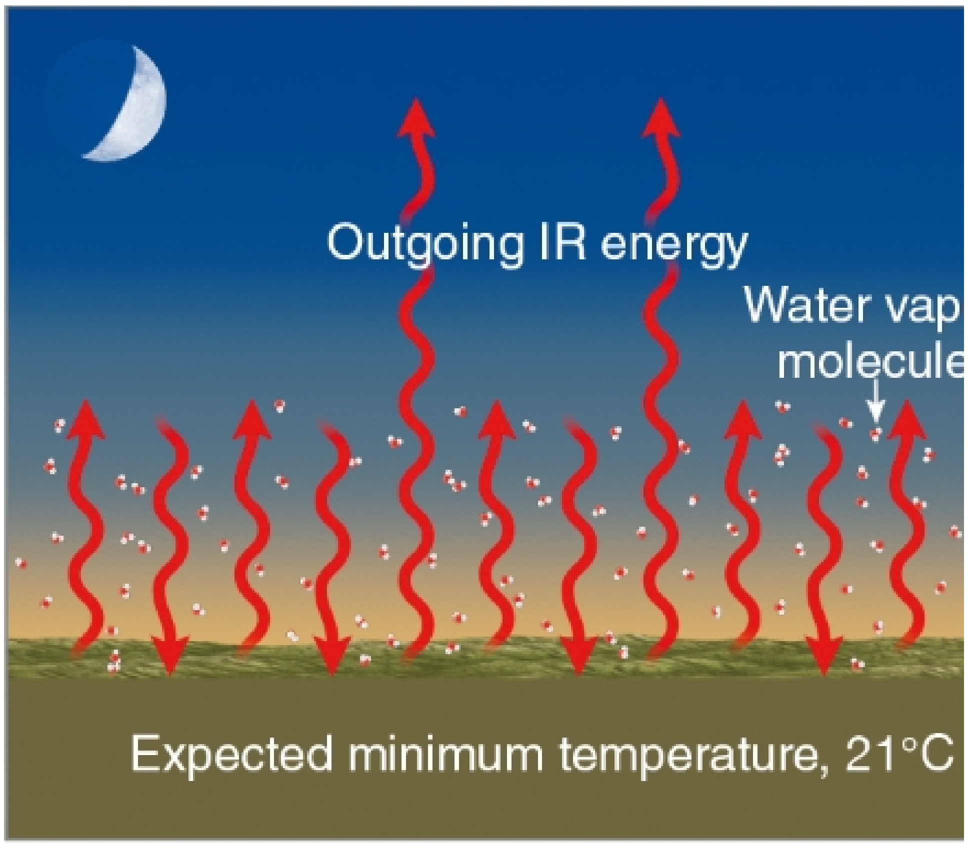
Date / Time (MDT)	Conditions	Temp (°C)	Humidity (%)	Dew Point (°C)
4 October 2011				
8:00	Fog	5	100	5
7:00	Fog	4	100	4
6:00	Fog	4	100	4
5:00	Fog	3	100	3
4:00	Fog	3	99	3
3:00	Cloudy	5	99	4
2:00	Cloudy	3	97	2

**particles causing "haze" may be dry or wet, and are not individually visible (Ahrens)

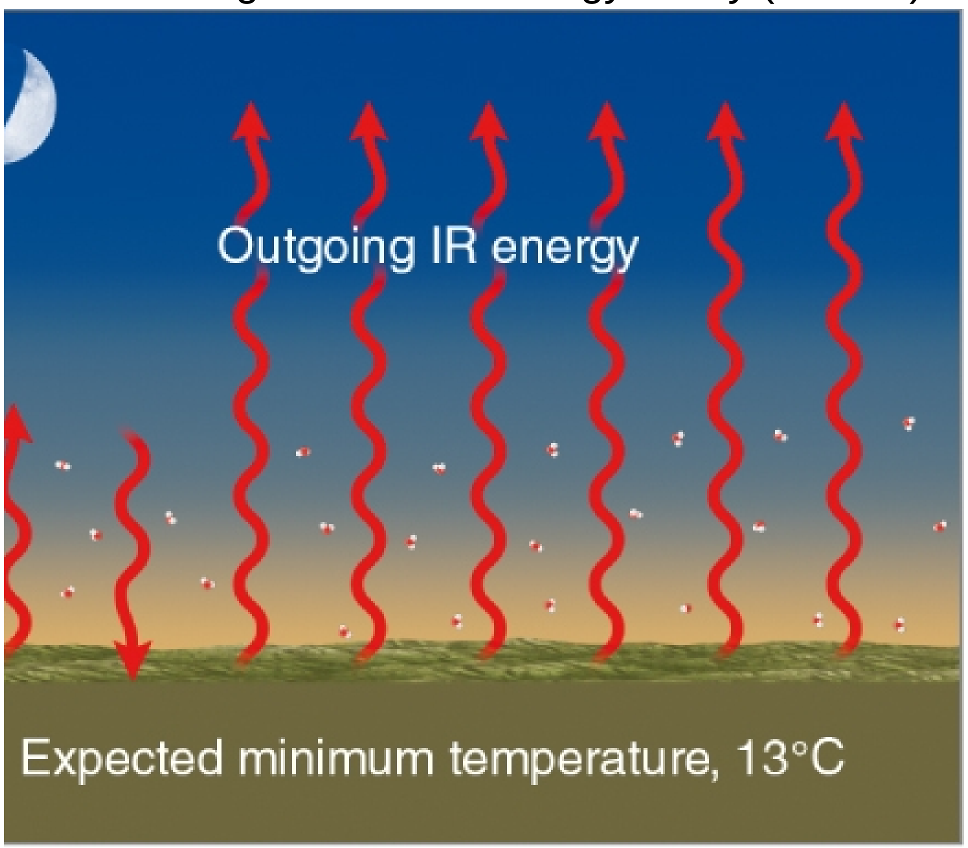
Higher T_d ⇒ plentiful vapour to trap $L\uparrow$ and emit $L\downarrow$

If cooling results in $T = T_d$, release latent heat and form haze/mist/fog that slow further cooling

image from Meteorology Today (Ahrens)



Dew point temperature, 20°C



Dew point temperature, 10°C

Equilib. v.p. over flat surface of pure liquid water (sometimes, ice) taken as "benchmark".

Normally in clear air $e < e_*(T)$

Table 7.2

Relative Measures		
Relative Humidity	$RH = \frac{e}{e_s} \times 100\%$ $RH = \frac{r}{r_s} \times 100\%$ $RH = \frac{\rho_v}{\rho_{vs}} \times 100\%$	a measure of how close the air is to being saturated; can be directly measured; reported as part of routine weather observations
Vapour Pressure Deficit	$VPD = e_s - e$	an indicator of the drying power of the air
Dew-Point Depression	$T_{dd} = T - T_d$	an indicator of how much the air needs to cool to reach saturation; labelled on 700 hPa charts

$$\text{RH} = 100 \; \frac{\text{actual vapour pressure}}{\text{equilib. vapour pressure}} = 100 \; \frac{e}{e^*(T)}$$

Analogy: your bank account allows an overdraft of $1000. Designate that overdraft limit by the symbol "OL".

Different people, or the same person at different times, have different numerical values for the variable whose symbol is OL.

You carry a certain amount of cash, "c" [$]. Perhaps at noon you have c=1.5 and since you wish to buy a magazine, you go to an ATM and withdraw $20. Now, c=21.5, until you buy the magazine.

You do not necessarily "have" or "carry about" an amount of money equal to OL. OL is, so far as your every day behaviour is concerned, only an idea. The reality in your pocket is the actual amount of cash, c. And OL is only relevant to c in as much as, potentially, you can augment c by drawing on your account, until such time as your account is overdrawn by the amount OL.

$$RH = 100 \frac{\text{actual vapour pressure}}{\text{equilib. vapour pressure}} = 100 \frac{e}{e^*(T)}$$

"benchmark"

Example: Suppose the air outside is saturated at -14ºC. Referring to Table 7.1,

$$e = e^* = 2 \text{ hPa} \qquad \text{(rounded)}$$

Your furnace is drawing this air into the house and heating it to 22ºC without adding vapour.

The actual vapour pressure *e* is unchanged**, but *e** increases to ?? 26.4 hPa

Inside your house, RH=??

$$RH = 100 \frac{2}{26.4} \simeq 8\%$$

**Assuming the mixing ratio and specific humidity (q=0.622 e/P) did not change, and that total pressure P is the same inside and outside.

Windsor Park, Edmonton

$$\text{RH} = 100 \frac{\text{actual vapour pressure}}{\text{equilib. vapour pressure}} = 100 \frac{e}{e^*(T)}$$

Example 7.9a: How much water vapour is in a sample of air with T=-2^{o}C and RH=95%? Give your answer as vapour pressure e [hPa] and as absolute humidity ρ_v [kg m^{-3}]. Extra: can you also determine T_d?

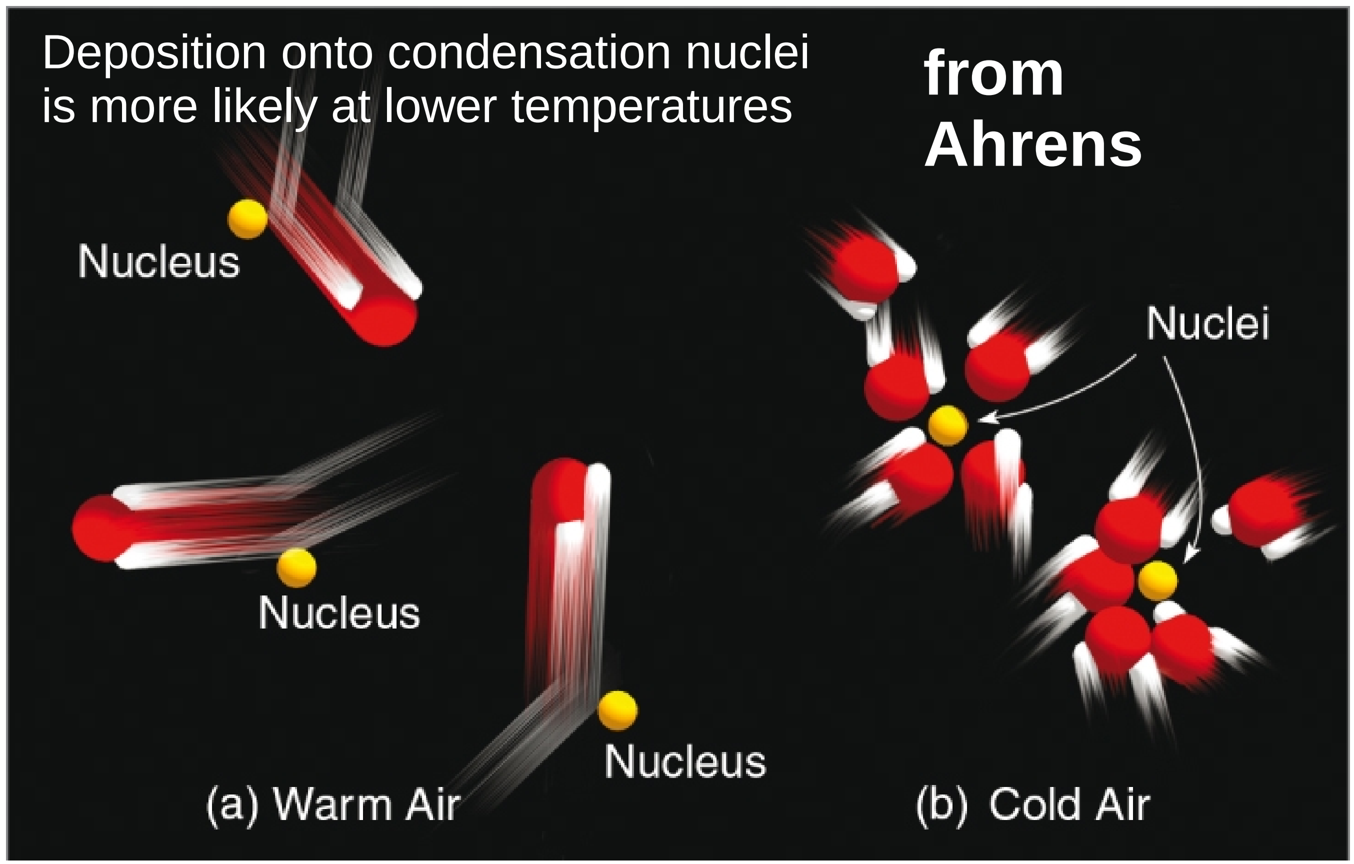
Example 7.9b: How much water vapour is in a sample of air with T=27^{o}C and RH=49%? Give your answer as vapour pressure e [hPa] and as absolute humidity ρ_v [kg m^{-3}].

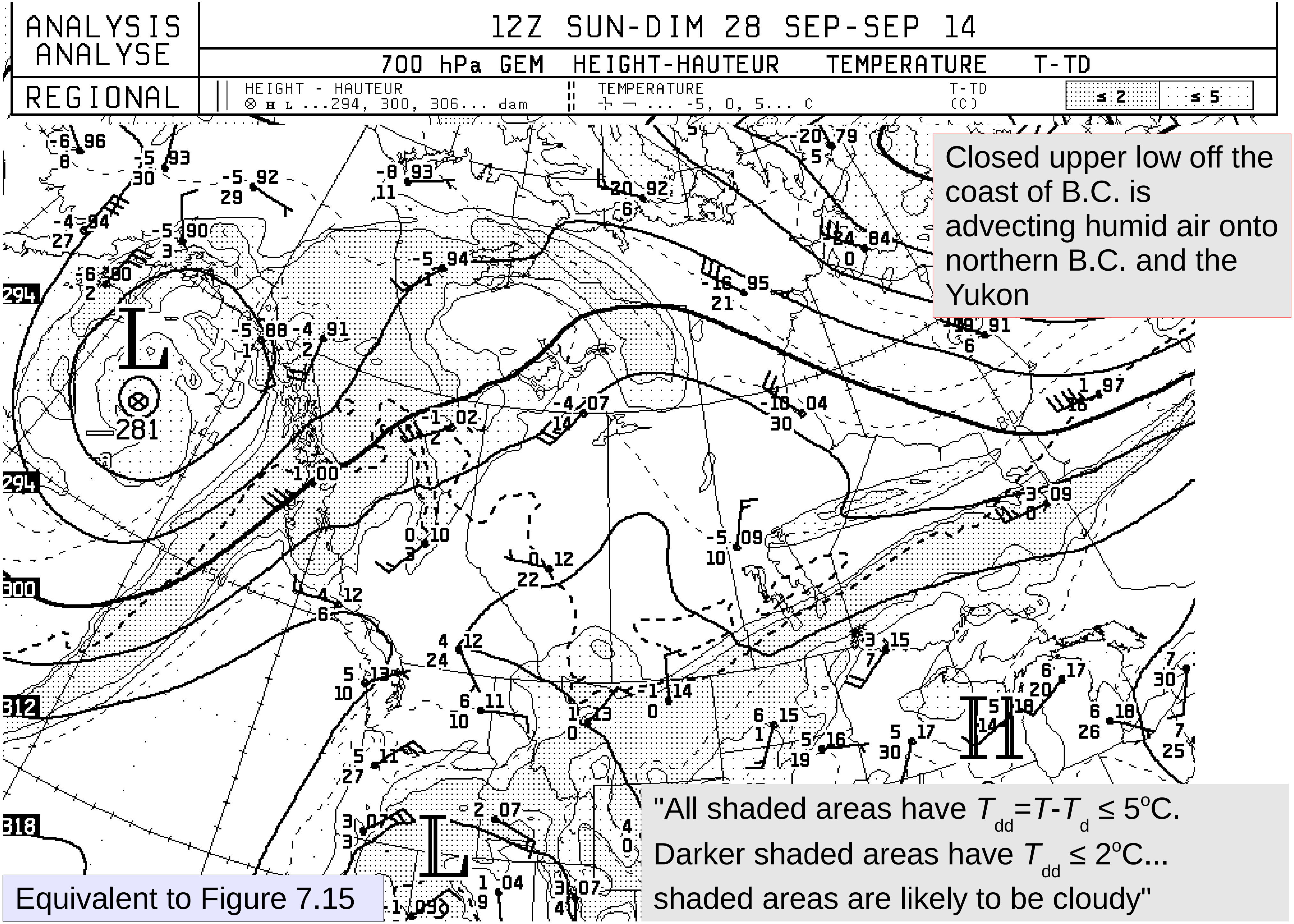
- air contains small particles that serve as "condensation nuclei"

- depending on the air's temperature and vapour pressure, water may condense (or deposit) onto these – **this can happen even if RH < 100%**

- a film of water on the particle is analogous to the water surface in the beaker – the "equilibrium vapour pressure" is that value of the partial pressure of water vapour needed to balance evaporation off the droplets

We shall later see (Ch9) that if the nuclei are very tiny, and if they are not "hygroscopic" (i.e. water-seeking) then the equlibrium v.p. is higher than over a plane sfc of water/ice – and air having such an elevated v.p. is "supersaturated"

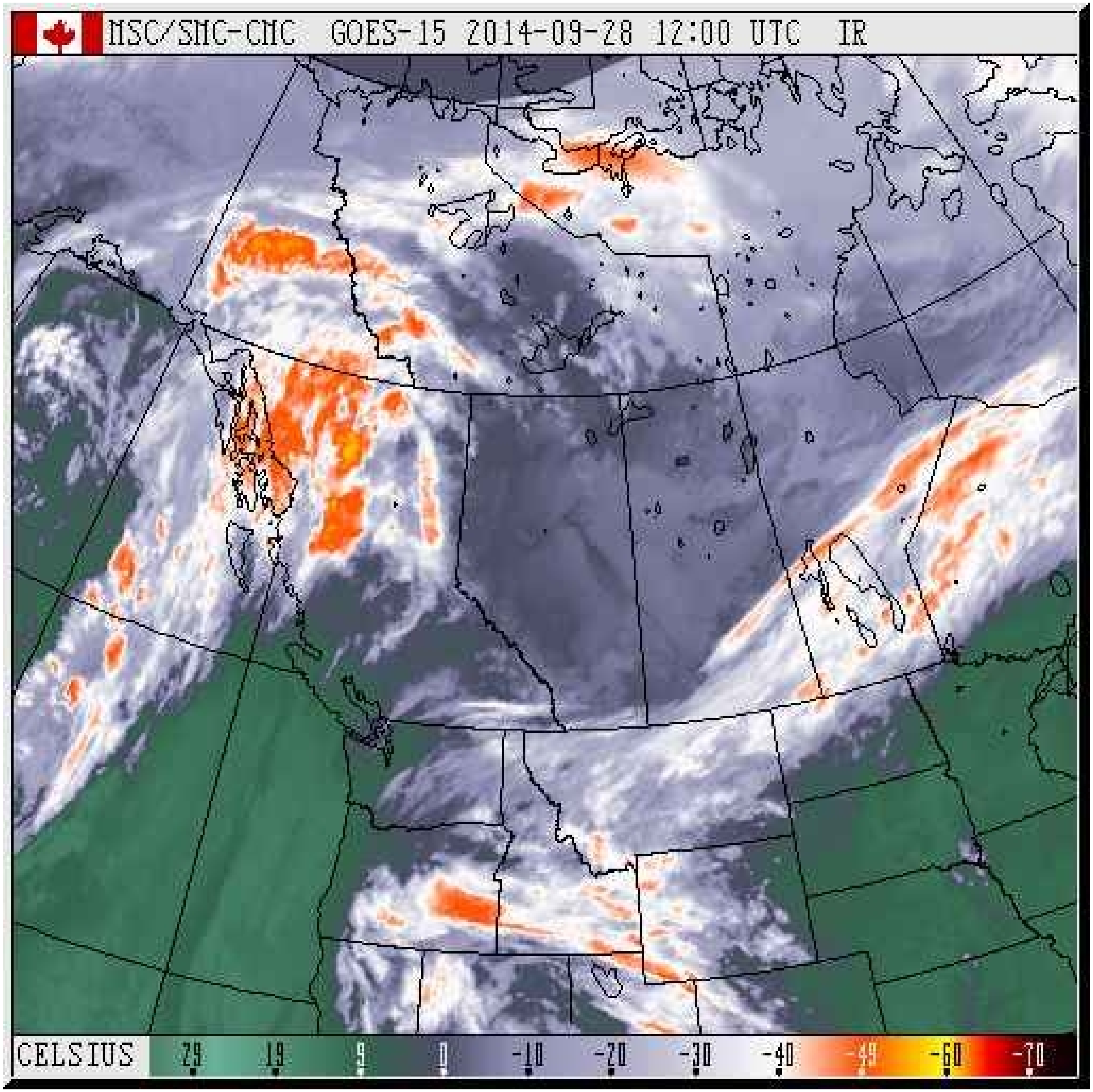




Closed upper low off the coast of B.C. is advecting humid air onto northern B.C. and the Yukon

"All shaded areas have T_{dd}=T-T_d ≤ 5°C. Darker shaded areas have T_{dd} ≤ 2°C... shaded areas are likely to be cloudy"

Equivalent to Figure 7.15



Geostationary Operational Environmental Satellite

Present "GOES West" launched Oct. 2010

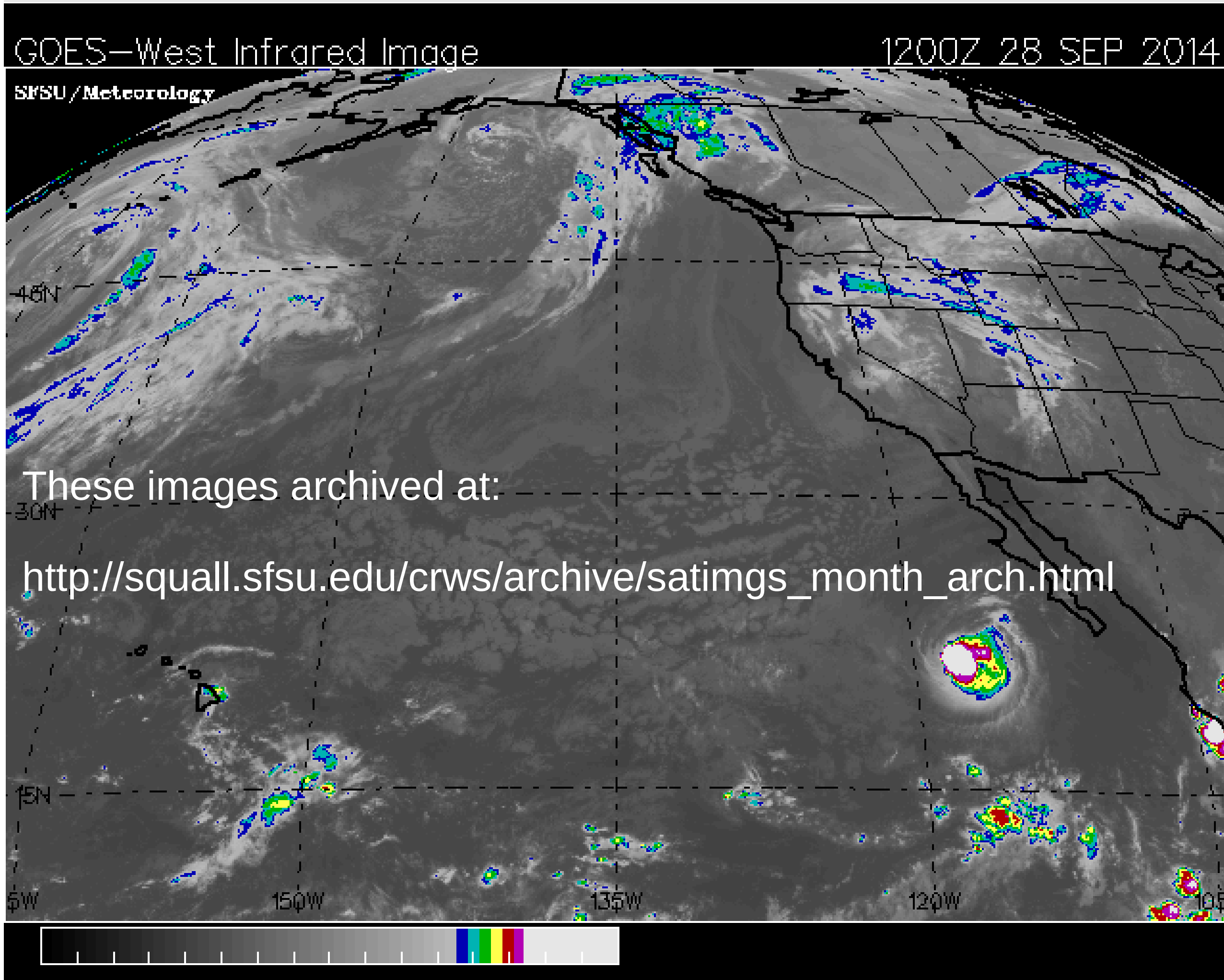
Orbits in earth's equatorial plane at 135°W over Pacific

Oblique view of high latitudes – optically corrected here to "nadir view"

Wavelength 10.7 µm (in the atmos. window)

Signal decoded to indicate temperature of emitter – ground or ocean or cloud top

GOES ir satellite image – slant view



These images archived at:

http://squall.sfsu.edu/crws/archive/satimgs_month_arch.html

because the vapour pressure is sufficiently high (in relation to temperature) as to have resulted in condensation of vapour, presumably onto aerosol particles, causing droplets that are scattering visible light.

FIGURE 7.8. This fog in New Glasgow, Prince Edward Island, has formed **because** the air is saturated."

Can we refine this caption by expanding on the cause of the fog. →

Topics/concepts covered

- practice the different ways one uses the $e^*(T)$ table
- clarification of meaning of "saturation" – nothing more than that the vapour pressure equals a certain reference or benchmark value e^*, a value, furthermore, that is defined in reference to the equilibrium state of a system that is nothing like the atmosphere (viz. a plane surface of pure water or ice)
- concept of "supersaturation," and what it means – viz. $e > e^*$
- relative humidity calculations
- representation of RH on the 700 hPa isobaric chart; recognising humidity advection