Goal for today: finish Ch. 1, “Composition & Structure”

12 Sept., 2011

- More on the variable gases
- Layers of the atmosphere, and their rationale
- Why is *pressure* so important to meteorologists?
- First look at a weather map – the “surface analysis”

From previous class: calculation to get a sense of the enormous amount of energy tied up in water vapour

How long ("*t* ") must you run a 100 W light bulb to consume 2.5 million Joules of energy (i.e. an amount sufficient to evaporate 1 kg of water)?

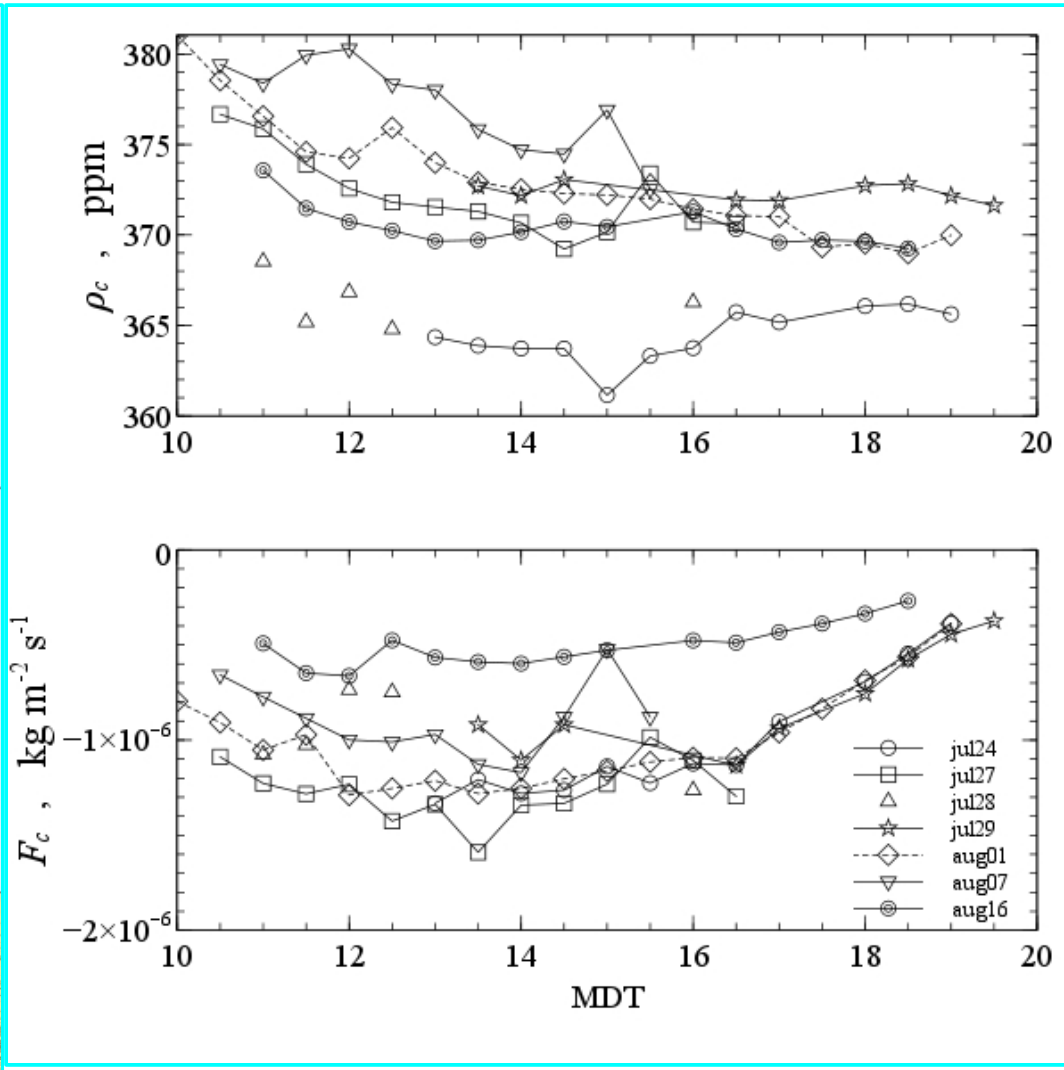
Given, energy *E*: $E = 2.5 \text{ x } 10^6 = 2{,}500{,}000 [\text{J}]$

Formula: $E = P\,t$

(where *P* = Power [W], *t* = time [s])

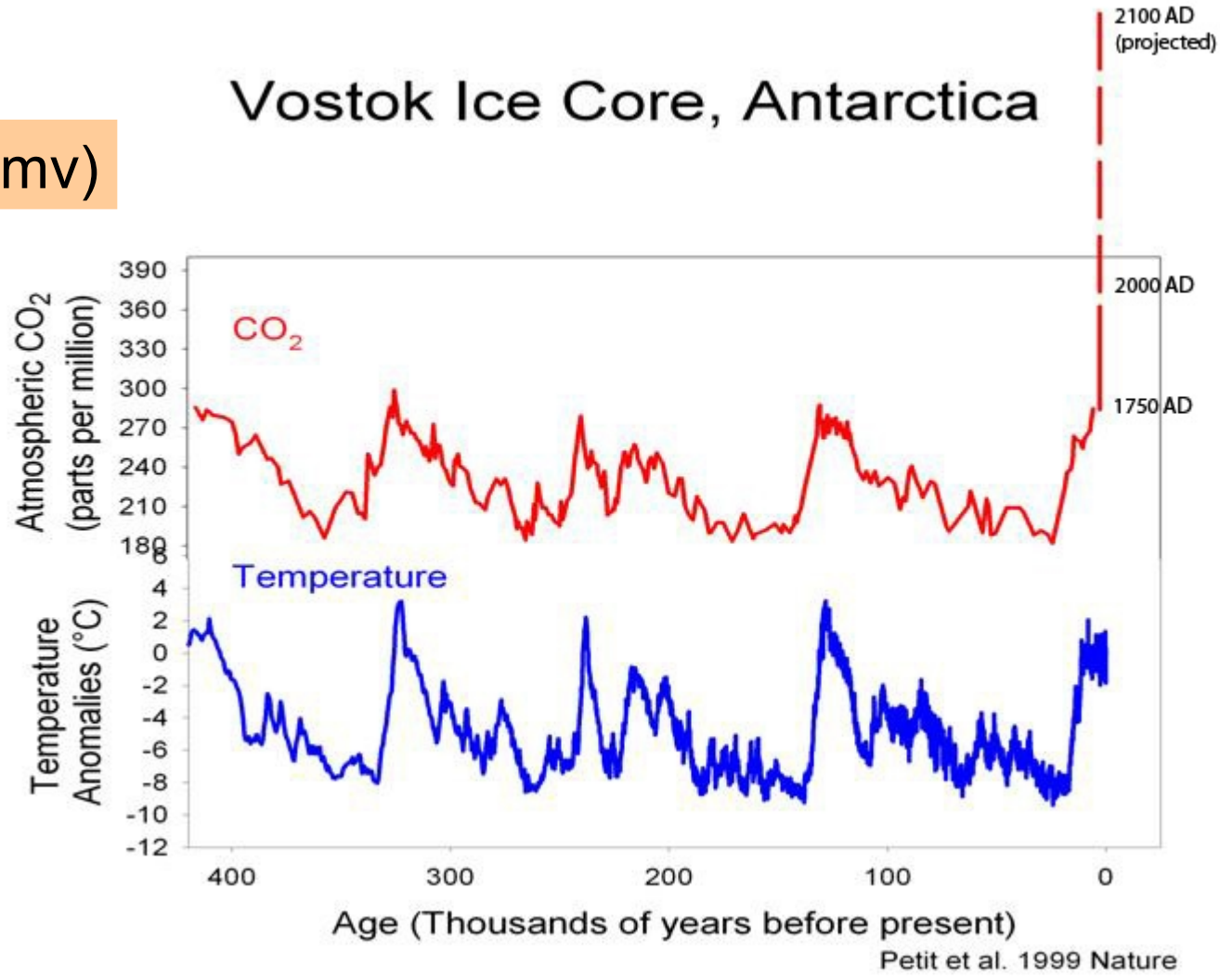
Unknown, time *t* : $t = \frac{E}{P} = 2.5 \text{ x } 10^4 \frac{[J]}{[J\,s^{-1}]} \approx 7 \text{ hr}$

Measured concentration and flux of CO_2 at St. Albert, 2011



- Wheat canopy is absorbing about 4 g per square metre per hour

(now 386 ppmv)

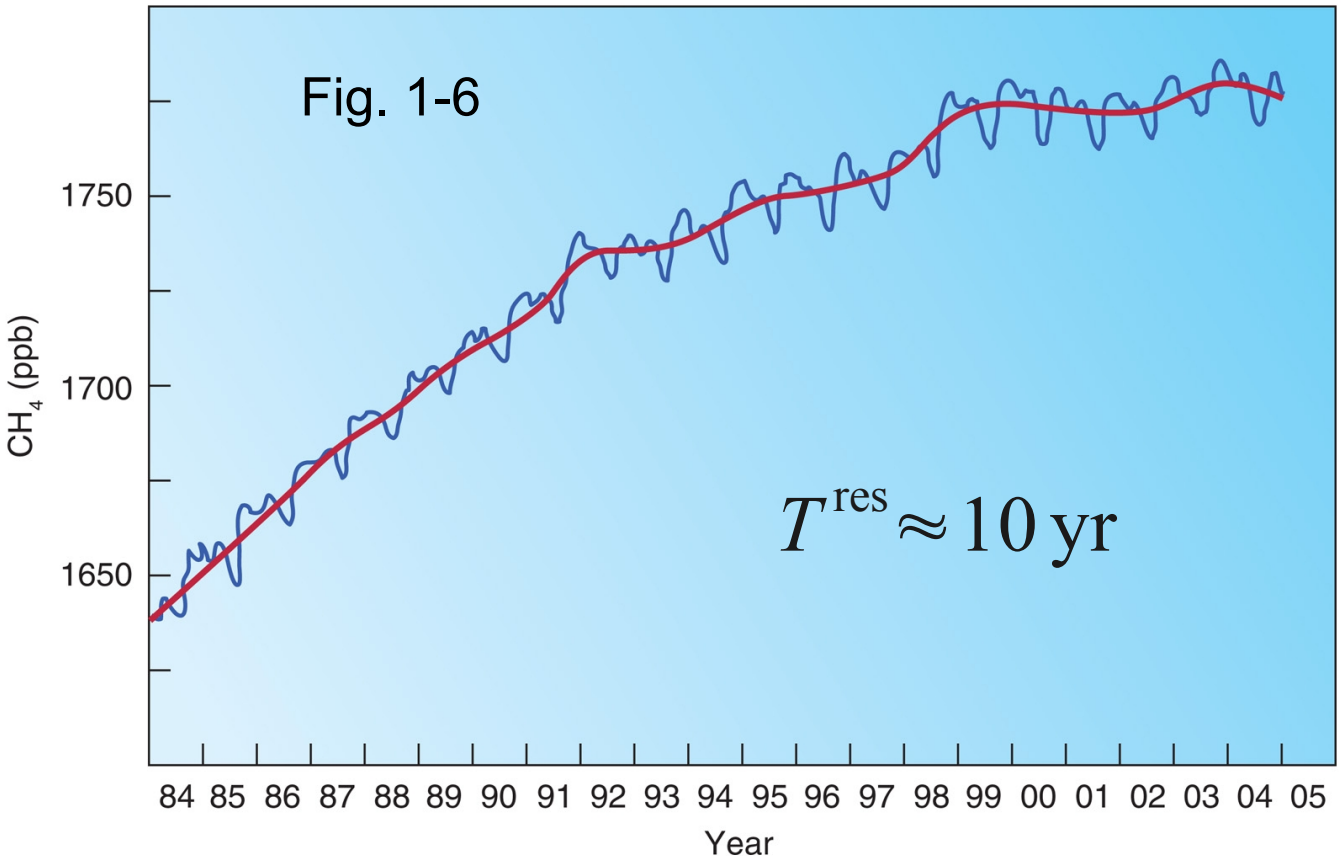


Dr Eric Wolff, British Antarctic Survey: “Ice cores reveal the Earth's natural climate rhythm over the last 800,000 years. When carbon dioxide changed there was always an accompanying climate change…”

CH_4 (methane) – a variable gas that is active

• another greenhouse gas; extremely effective because interacts with invisible "terrestrial" (i.e. "longwave" or "thermal") radiation at a wavelength where atmos. otherwise would be transparent**

• sources: anaerobic decomposition, rice cultivation, biomass burning, cattle, fossil fuel extraction, vents on ocean floor (thawing permafrost?)

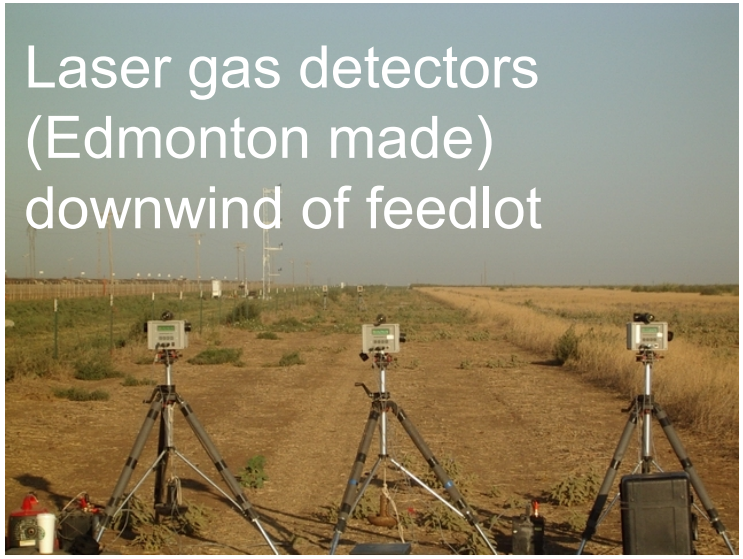


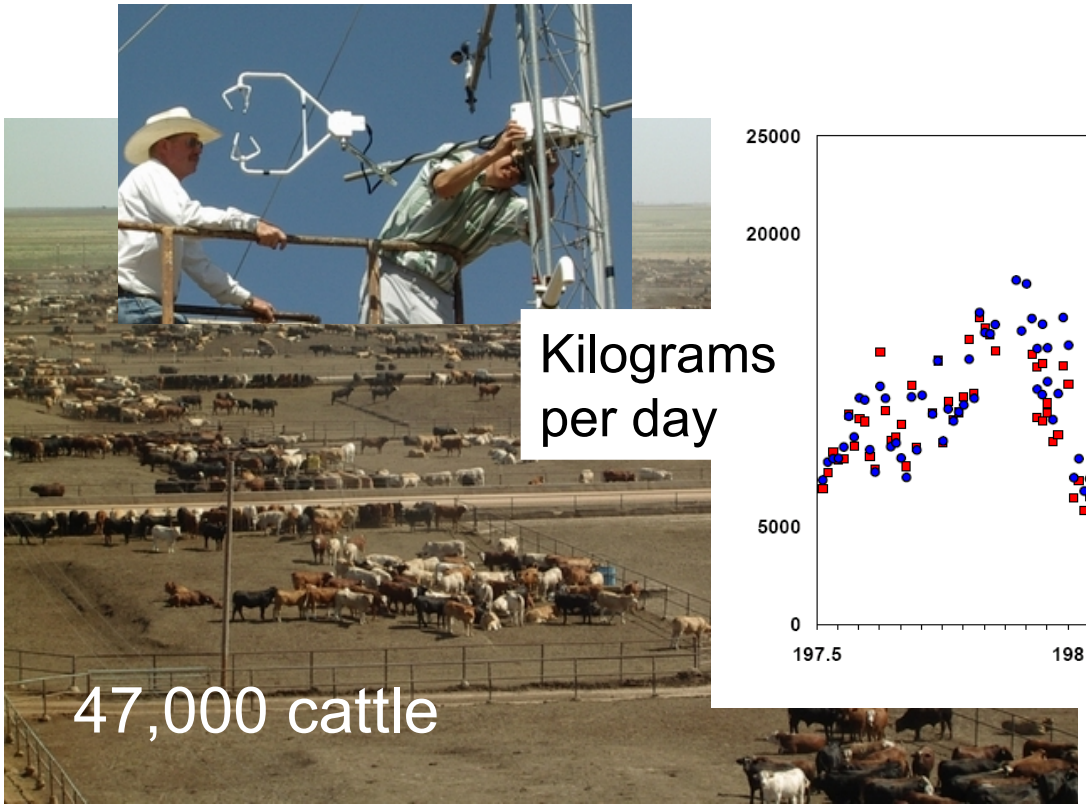
← Stabilized?

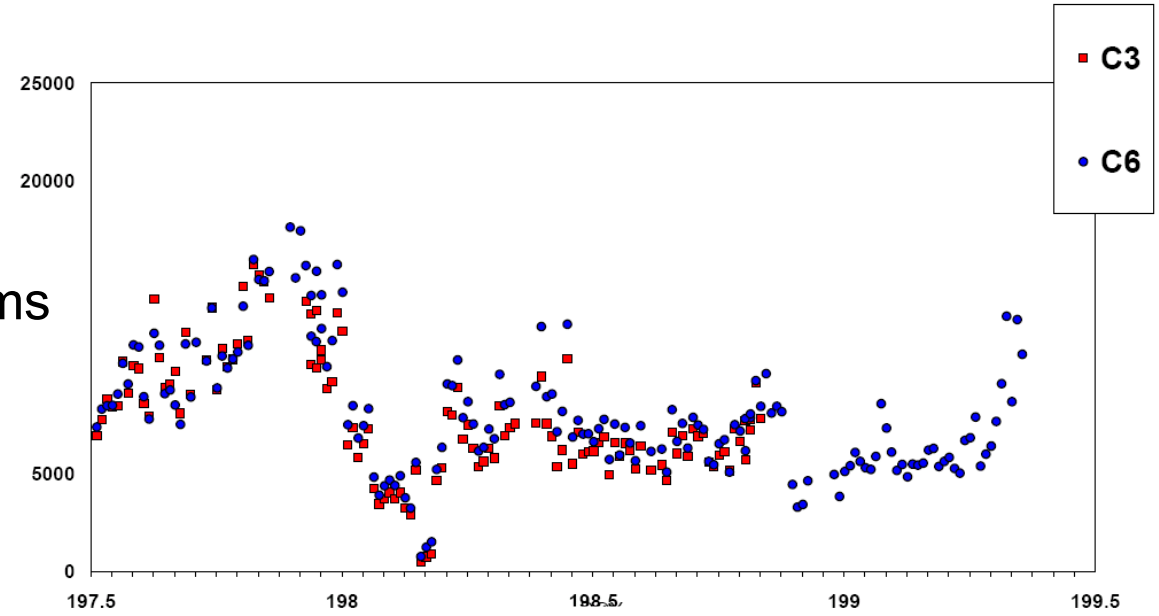
**Analogy: all your loonies and quarters have been robbed. The next loonie robber doesn't bother you, but a dime-robber does

Aside: measuring methane emission from a feedlot … UA team

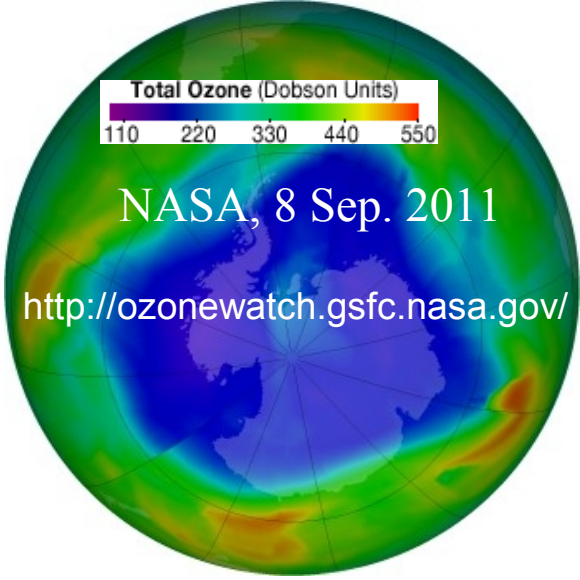
- laser measures gas concentration "*C*"
- anemometer measures wind
- numerical model calculates wind paths from pens to laser and infers emission rate "*Q*"







O_3 (ozone) and the ozone hole



- radiatively active (accounts for the differing temperature "lapse rate" in the stratosphere)
- inactive relative to weather
- essential relative to life… absorbs ultraviolet radiation
- peak concentration of up to about 15 ppm in mid-stratosphere (z ~ 25 km)

Simplified action of chlorine (Cl) causing ozone depletion – involves Chlorine monoxide ClO

$$Cl + O_3 \rightarrow O_2 + ClO$$

$$ClO + O \rightarrow O_2 + Cl$$

- depletion in spring over poles (esp. Antarctica, decoupled from rest of hemi.)
- reactions on surface of polar stratospheric ice clouds
- over long term, size of hole governed by emissions of CFCs (T^{res} ~ 100 yr)
- year-to-year variability determined mostly by temperature variations (NASA)

Aerosols

- size 0.1 μm → 100 μm or larger (smallest formed from sulphate gases)
- reduce visibility (scatter solar radiation)
- trap outgoing longwave radiation
- function as “cloud condensation nuclei”

UA farm
Ellerslie
28 May 2001

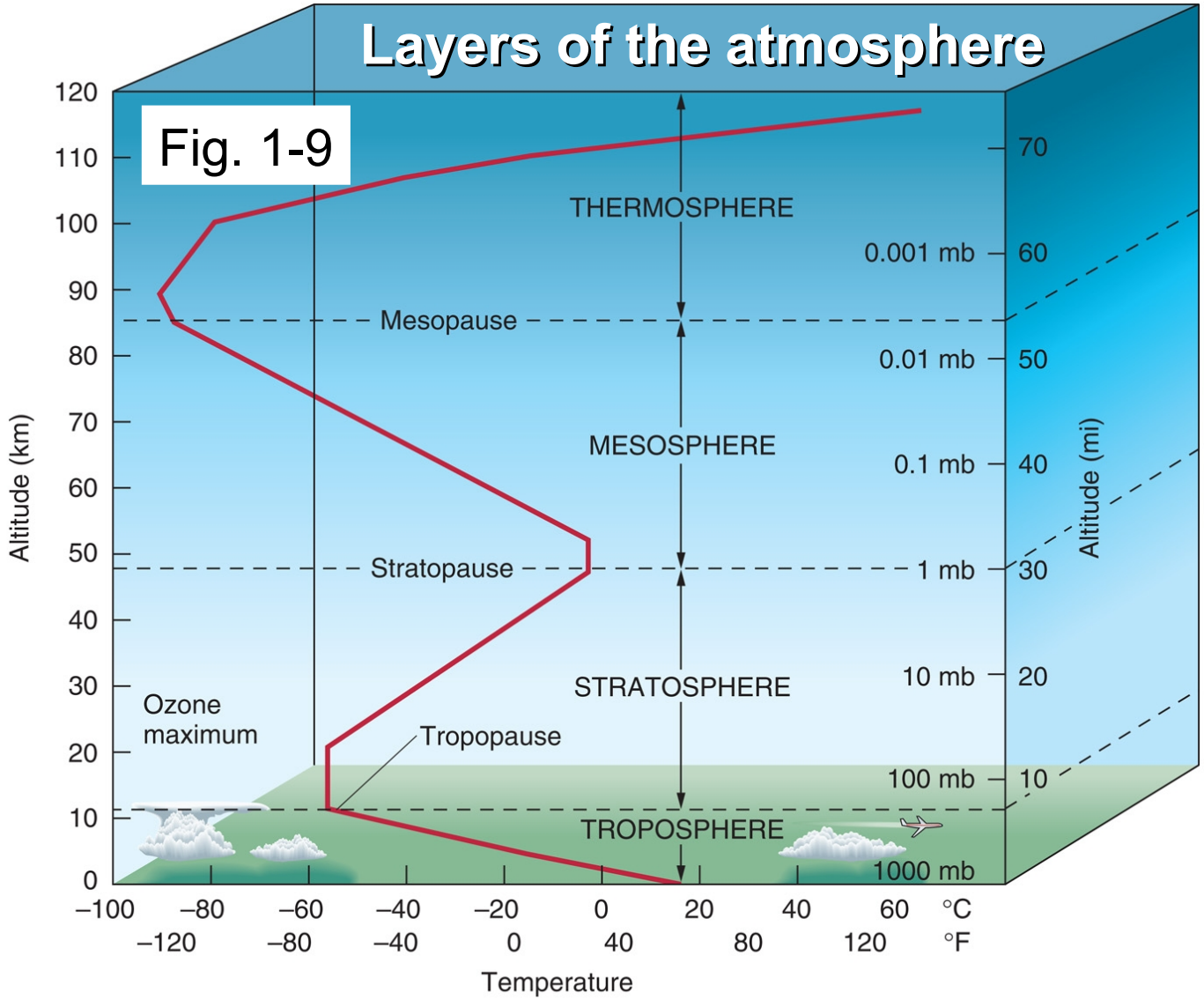
Aside: dust is hugely important
To weather on Mars (absorbs radiation).
True or false? – Phoenix mission
proved it snows on Mars?

An uncertain feedback in climatic modelling: DMS (dimethyl sulphide) gas released by decay of ocean biota generates aerosol with radiative impact as well as acting as cloud condensation nucleii (CCN)

1^{o}C reduction in N. hemisphere sfc temp a year after Pinatubo eruption 1991

Vertical structure of atmos. – the climatological temperature profile

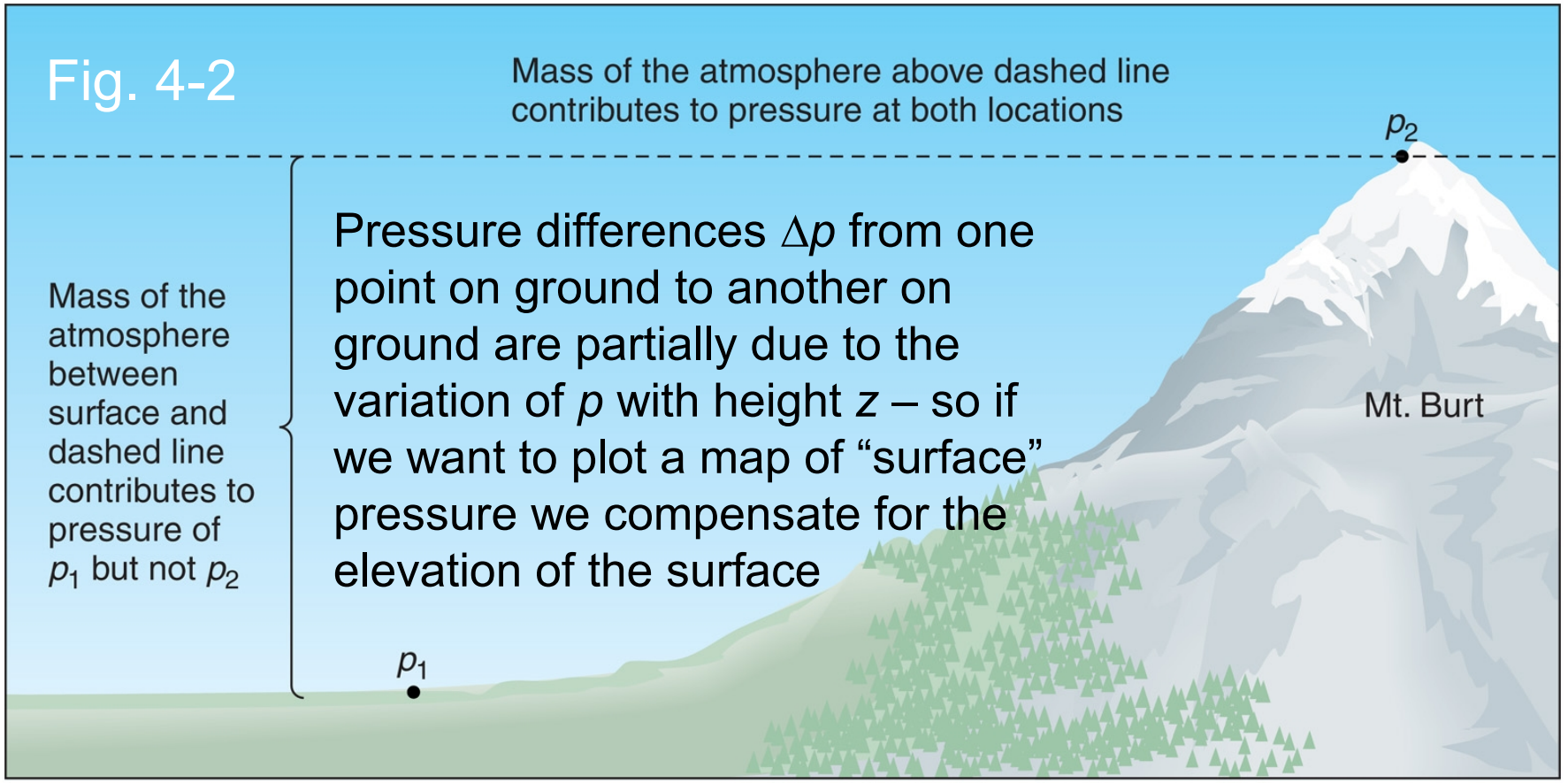
… where/why does heating occur?



We shall neglect these layers – irrelevant to weather

Weather. Lapse rate about 6.5 K/km

Now the “Weather Basics” of Ch 1…



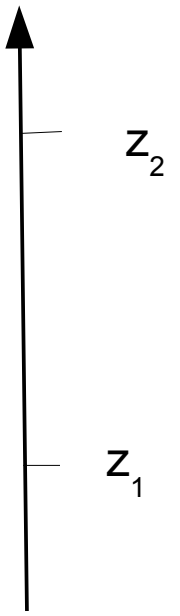
Pressure p = weight of overlying air per unit area A = $M\,g\,/\,A$ [Pascals]

(So about half the mass of the atmosphere lies below the 500 hPa level)

Relationship between pressure at a given elevation and the mass of air above that level:

p = weight of overlying air per unit area A = M g / A [Pa]

$p \propto M$ implies that $\frac{p_1}{p_2} = \frac{M_1}{M_2}$



If z_1 is sea level then p_1 ~ 1000 hPa and M_1 represents 100% of the atmospheric mass

Now if we seek to know what fraction of mass lies above level z_2 where p_2=700 hPa, then:

$$\frac{M_2}{M_1} = \frac{p_2}{p_1} = \frac{700}{1000} = 0.7$$

(i.e. 70%)

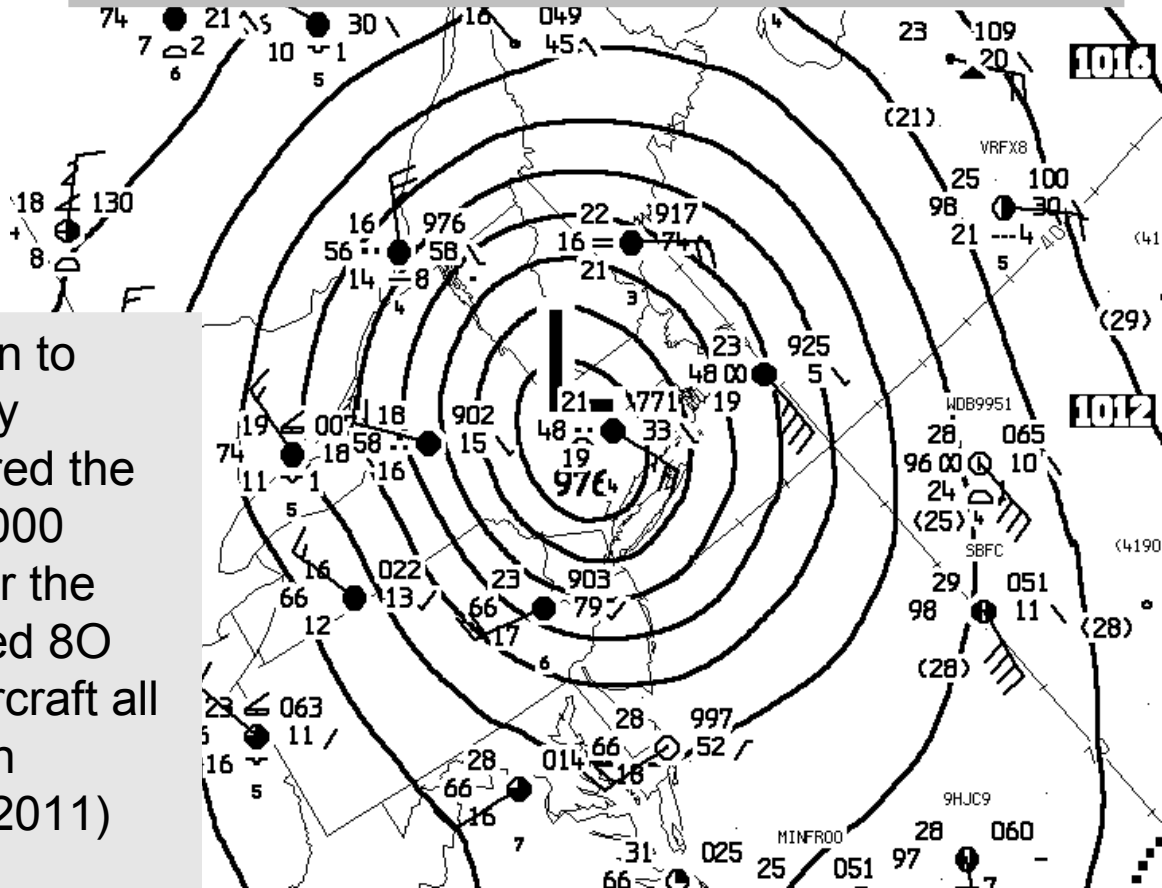
“Weather Basics” of Ch 1…

On the large scale, horizontal variation in pressure controls speed and direction of the horizontal wind, as well as the (much smaller) vertical wind – thus the spatial pattern of pressure correlates with the weather

As pressure *p* is so important, the weather analysis charts join points having equal pressure with “isobars” – which are simply isolines of pressure (p20)

MSC surface analysis 18Z Sun 28 Aug. 2011

- Recall MDT (our time) is currently Zulu - 6

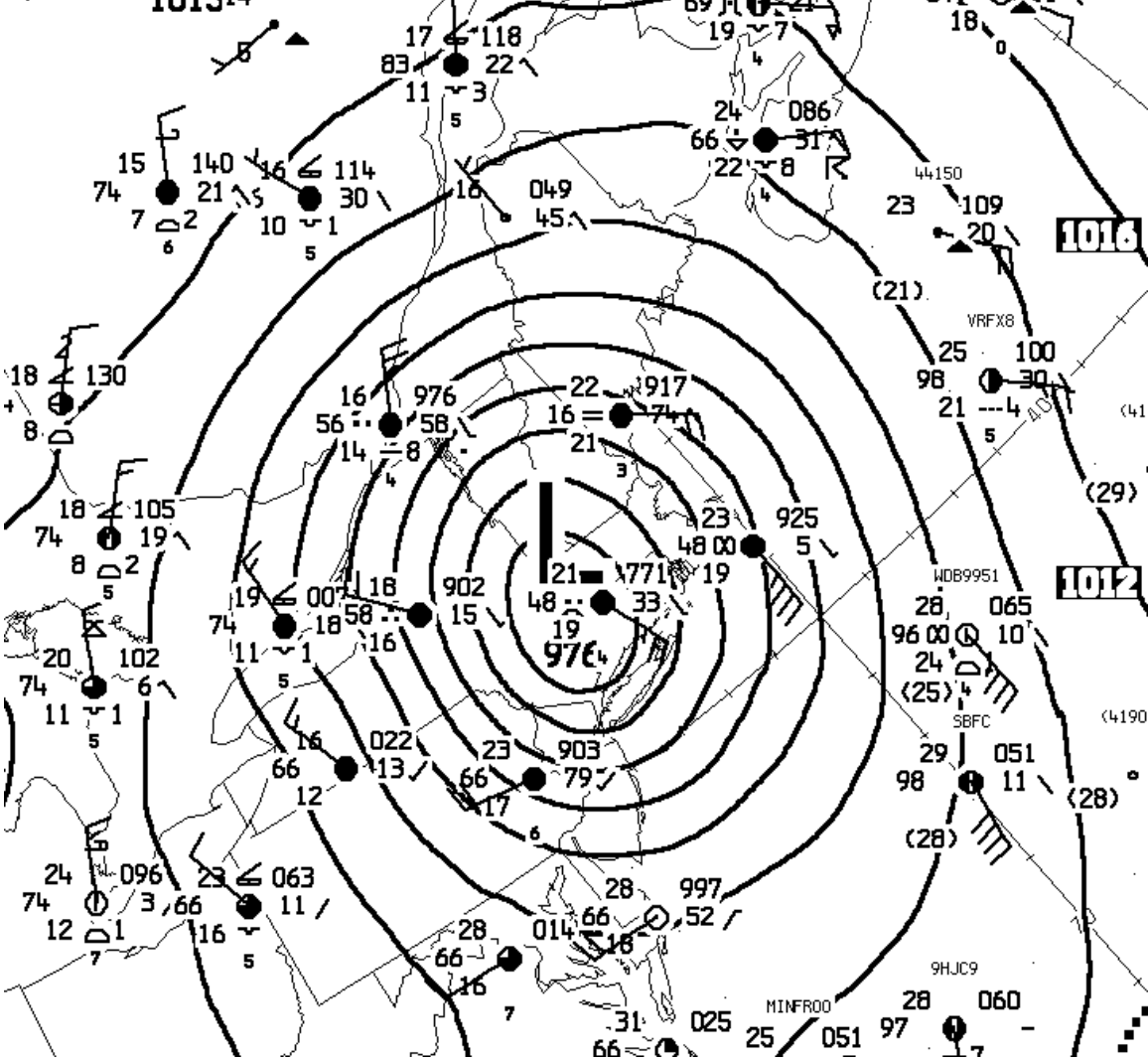


“The force of Hurricane Irene began to build in New York City early Sunday morning... Mayor Bloomberg ordered the unprecedented evacuation of 370,000 people living in neighborhoods near the water’s edge... The storm unleashed 8O miles per hour winds, grounding aircraft all along the heavily populated eastern seaboard.” (Toronto Sun, 28 Aug. 2011)

- In N. hemisphere winds blow anticlockwise about a region of low pressure

- Wind barb indicates where wind blows **from**

- The closer together the isobars are packed, the higher the wind speed



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EDT=Z-4

"More than 100 flights at Toronto's Pearson International Airport have been cancelled..." (Toronto Star, Sunday 28 Aug. 2011)