

A golden-yellow landscape with a bright sun, a lightning bolt, and mountains. The scene is dominated by a warm, monochromatic yellow-gold color palette. In the upper left, a bright sun is partially obscured by dark, silhouetted clouds. A jagged lightning bolt strikes down from the upper right towards the center. The foreground is a textured, dark brownish-grey ground, possibly a desert or rocky terrain. In the middle ground, several dark, rounded mountain peaks are visible against the hazy sky. The overall atmosphere is dramatic and intense.

TUTORIAL

Venus: The Atmosphere,
Chemistry, and Clouds

F.W. Taylor
Oxford University

Table X.3 Composition of the Lower Atmosphere of Venus

Species	Abundance (mole fraction)	Species	Abundance (mole fraction)
CO ₂	0.965	He	12 ppm
N ₂	0.035	Ne	7 ppm
SO ₂	150 ppm	H ₂ S	3 ppm
Ar	70 ppm	HCl	400 ppb
CO	30 ppm	Kr	30 ppb
H ₂ O	20 ppm	HF	5 ppb

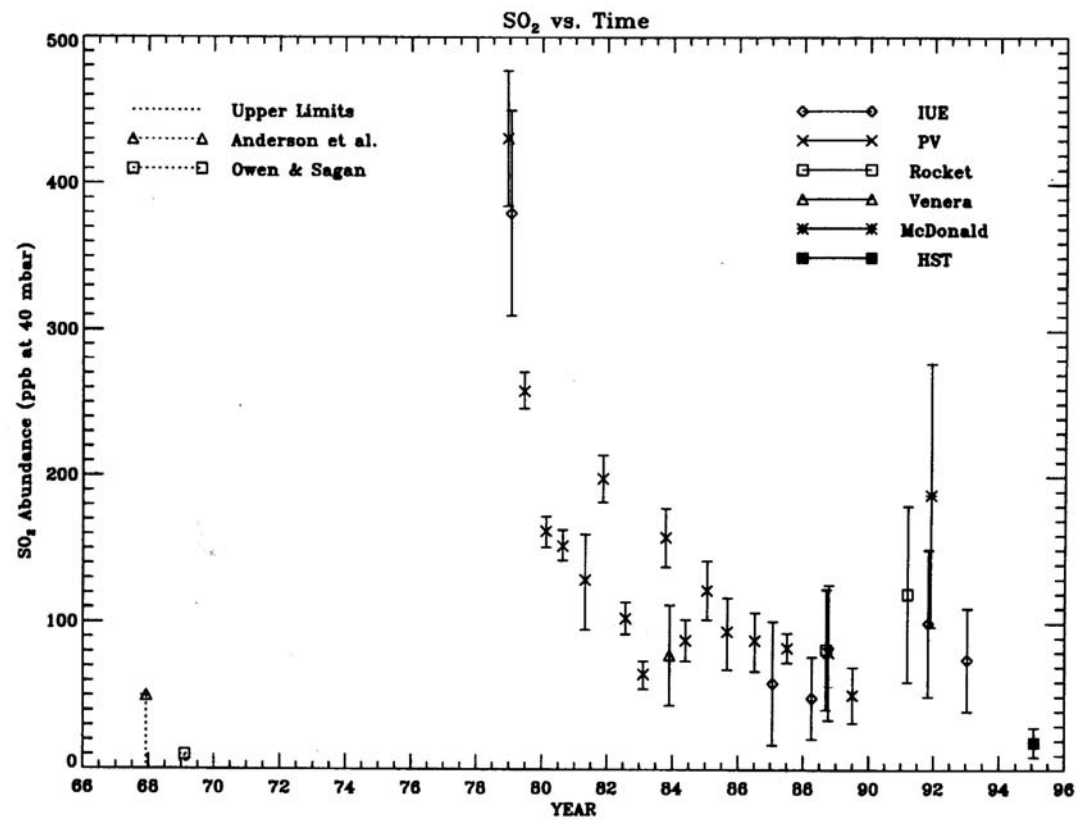
From 'Physics and Chemistry of the Solar System' by John S. Lewis

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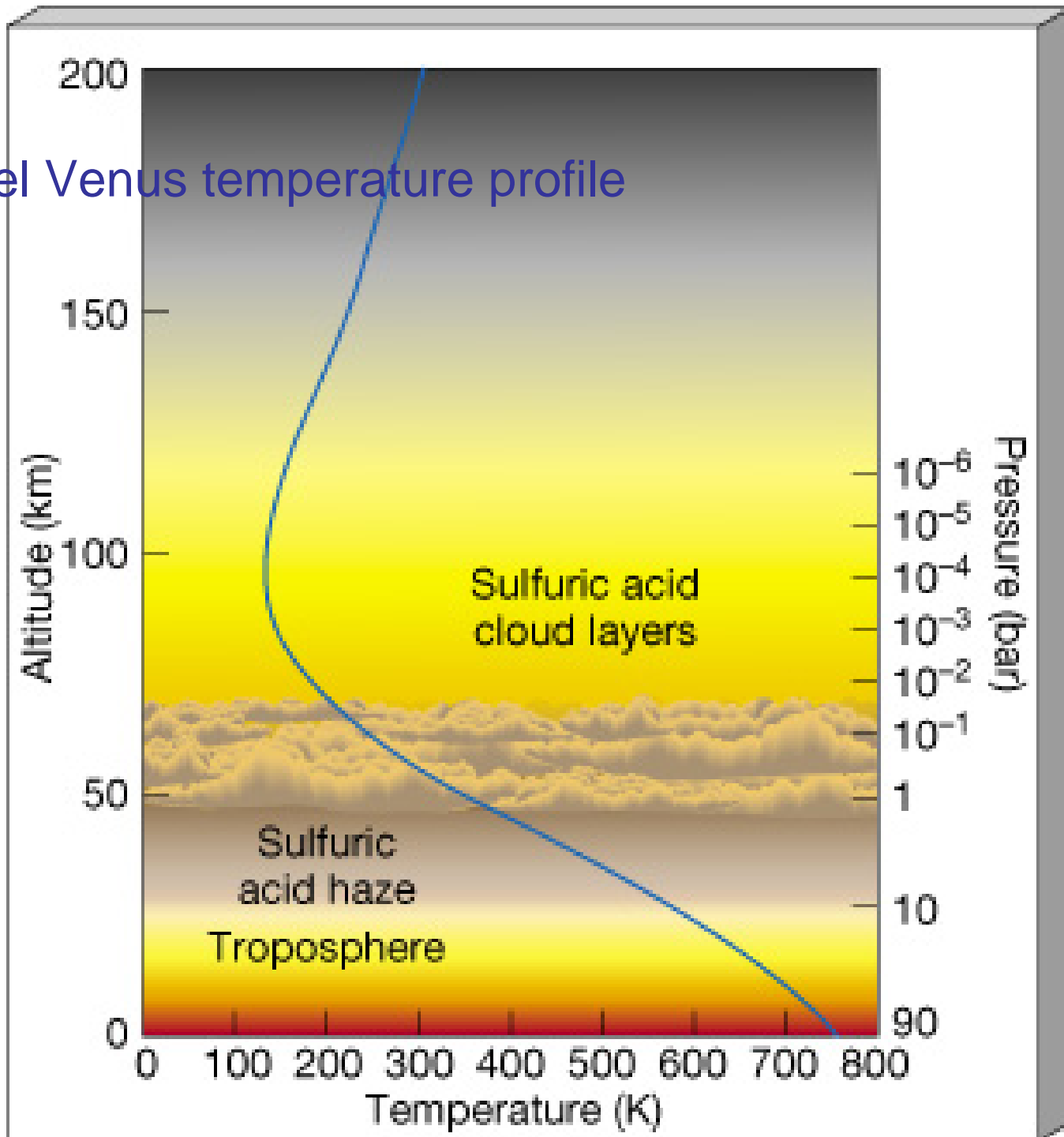
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- CO₂ and N₂ amounts ~‘same’ as the Earth
- Water very low (⇒ loss rate is high)
- D/H = 100 x Earth ⇒ possible ancient ocean
- Abundant SO₂, H₂S, H₂SO₄ ⇒ active volcanism?
- Some species are variable

SO₂ vs. Time (Na & Esposito, 1996)

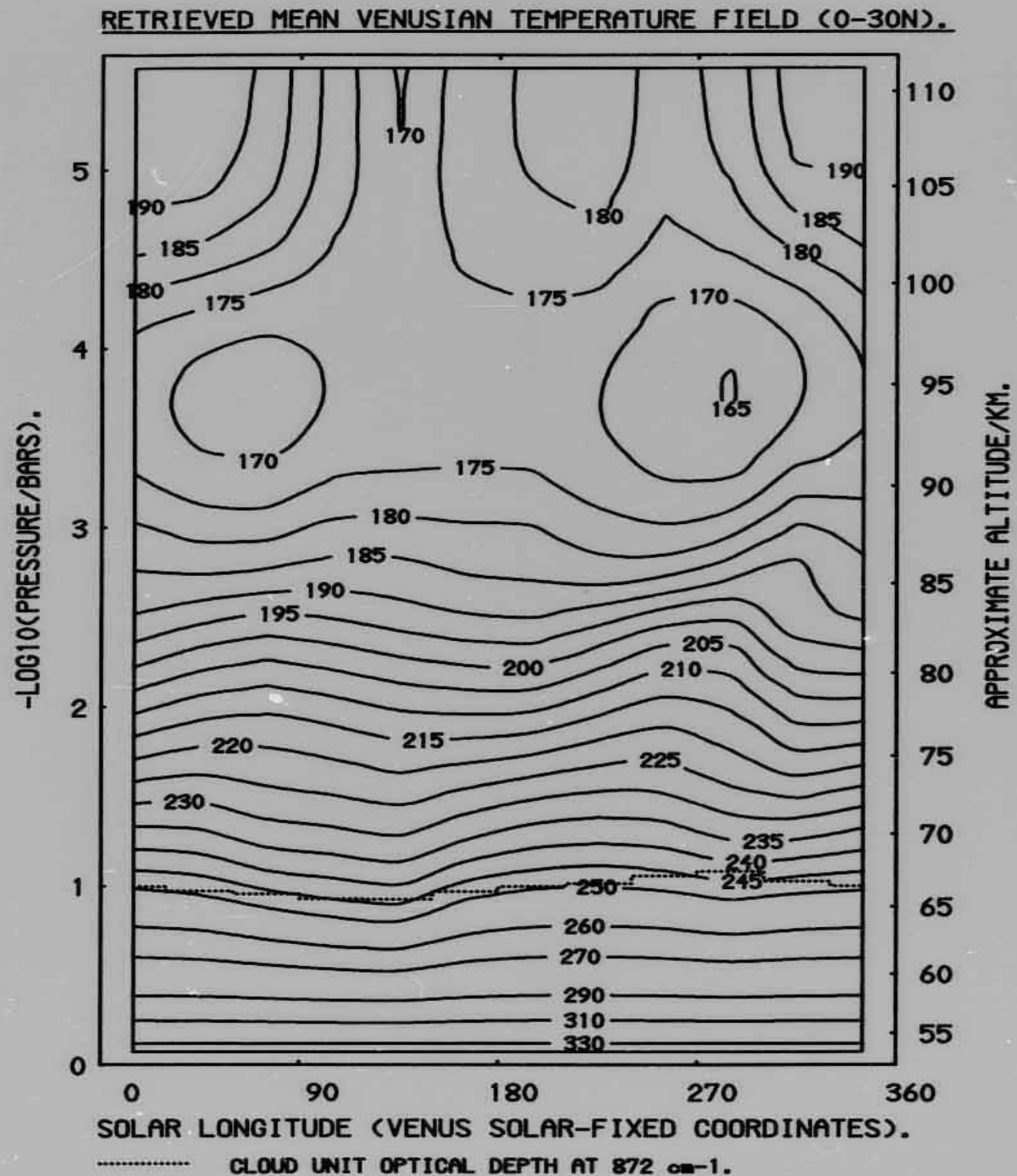


Model Venus temperature profile



Pioneer
Venus OIR
Measured
Temperatures
(3-month
mean)
vs.
Height &
Longitude
at 0° latitude

(Schofield & Taylor,
1982)

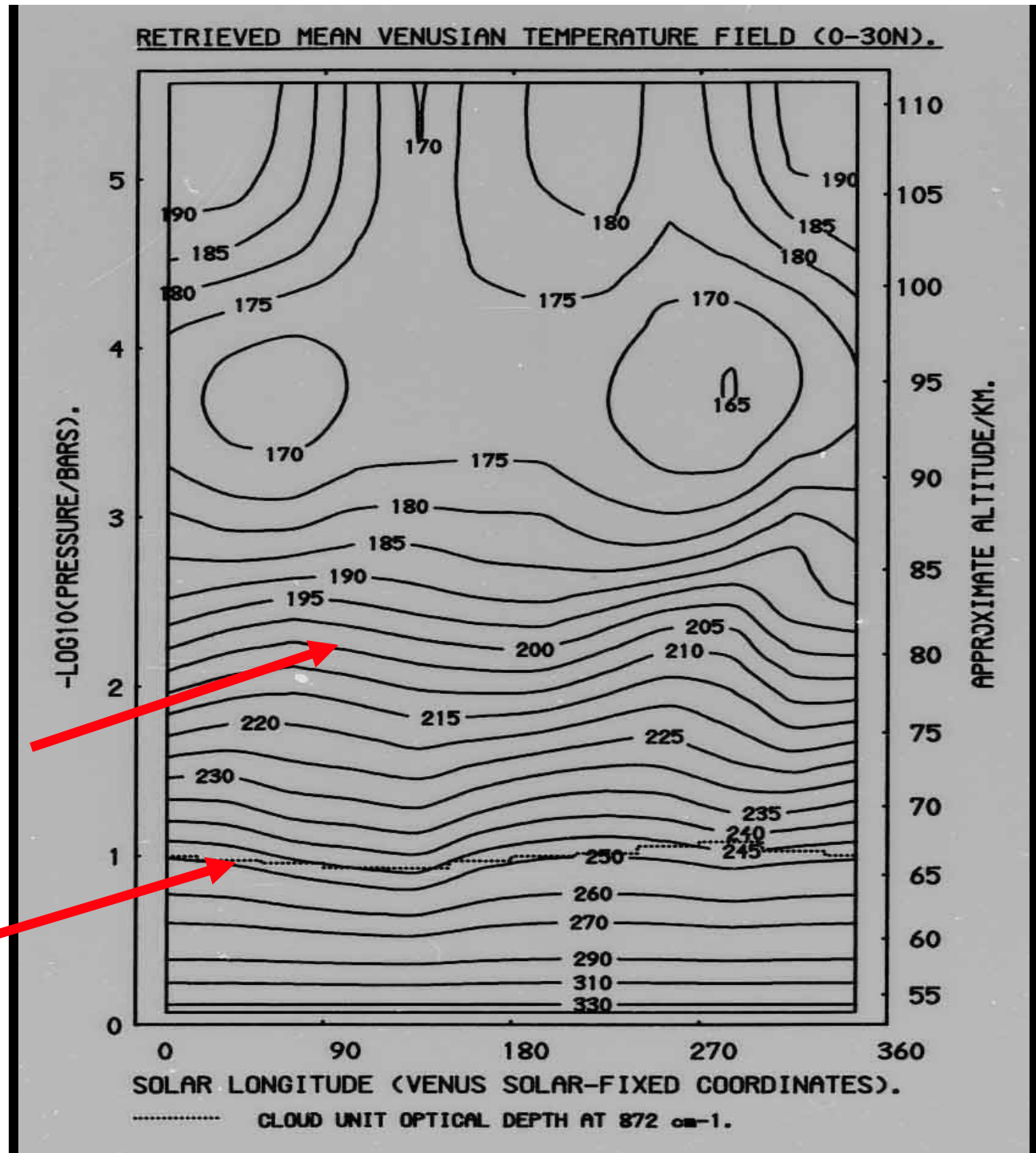


Pioneer
Venus OIR
Temperatures
vs.
Height &
Longitude

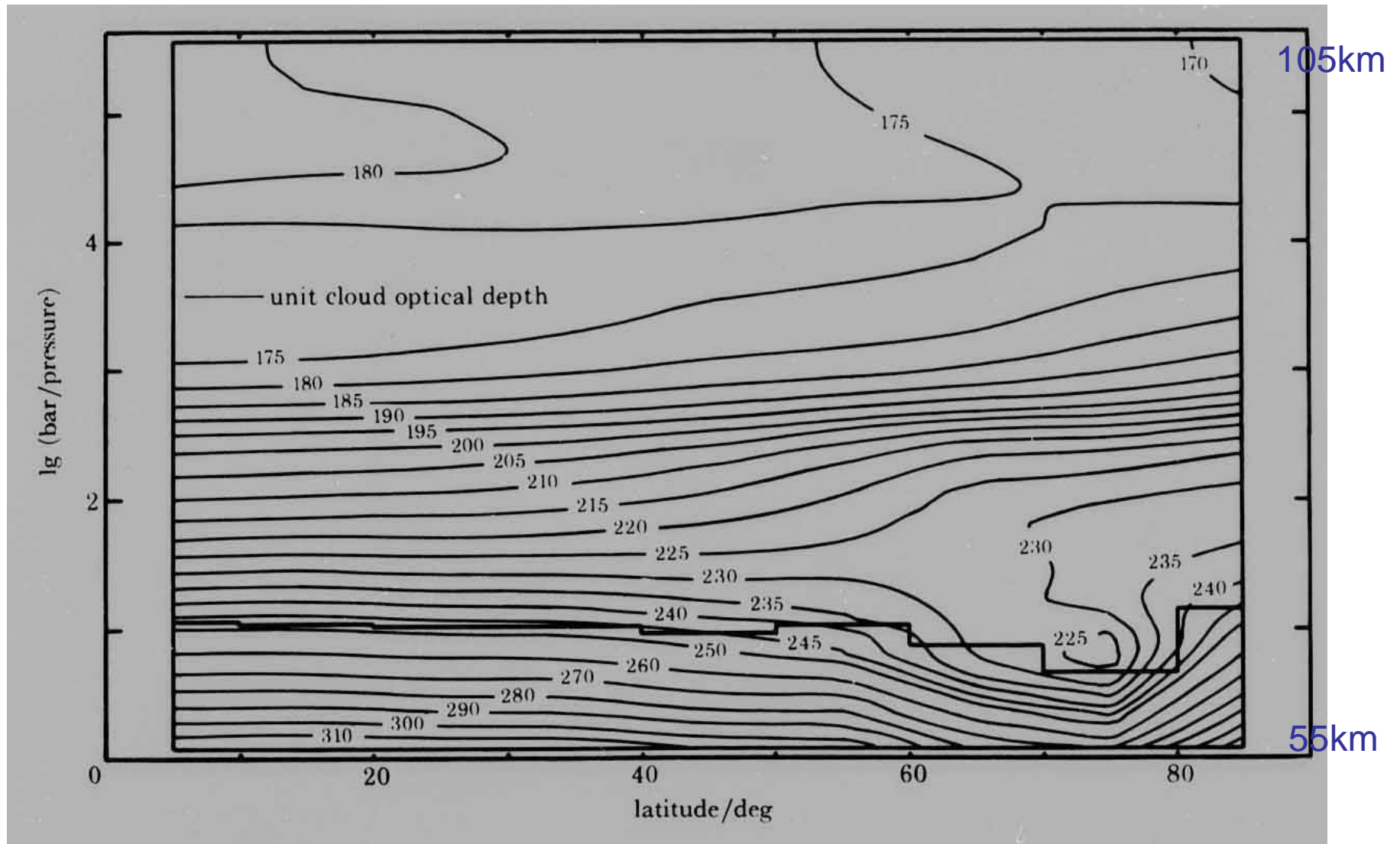
Solar Tide

- wavenumber 2
in stratosphere

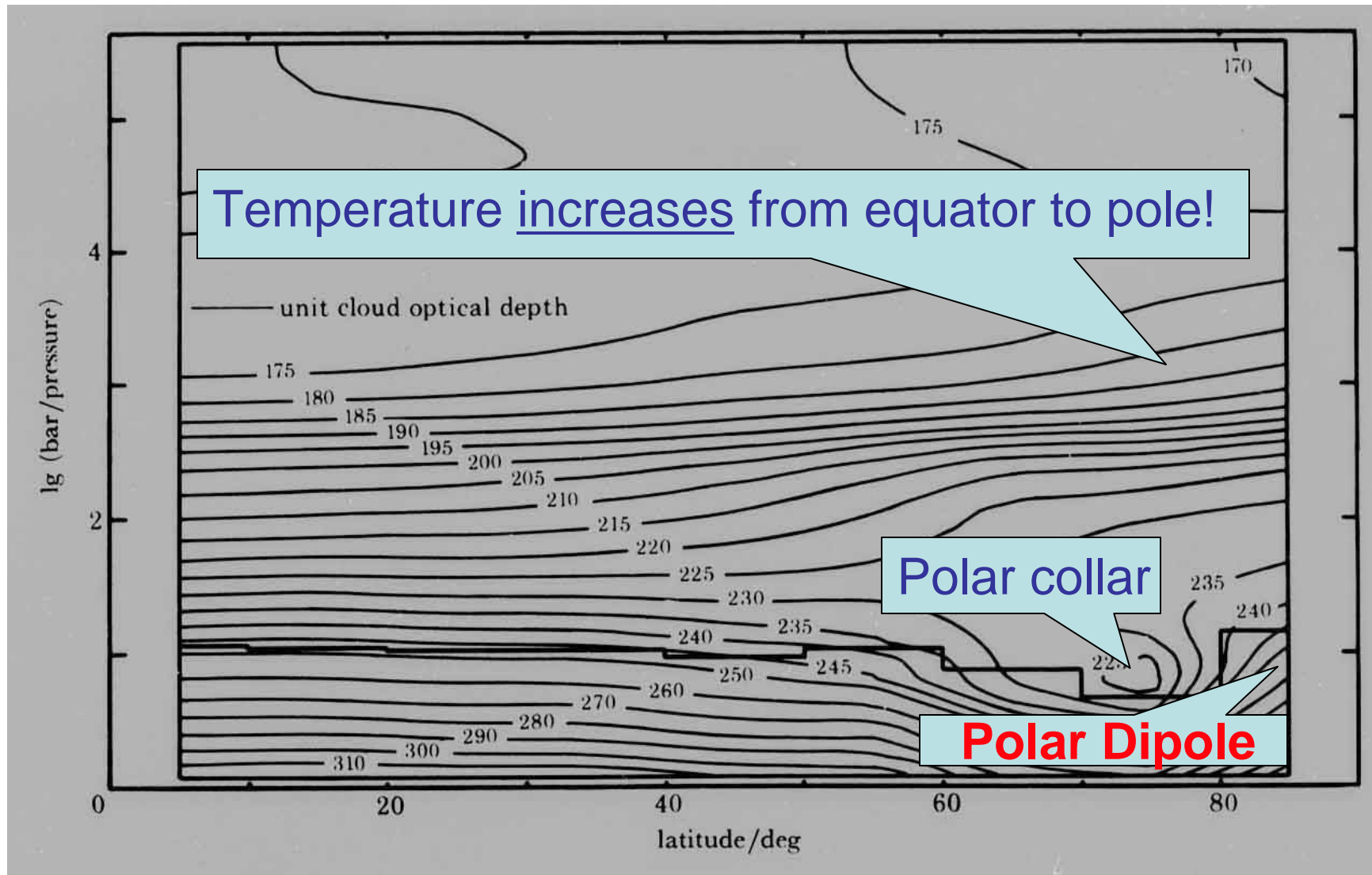
- wavenumber 1
at cloudtops

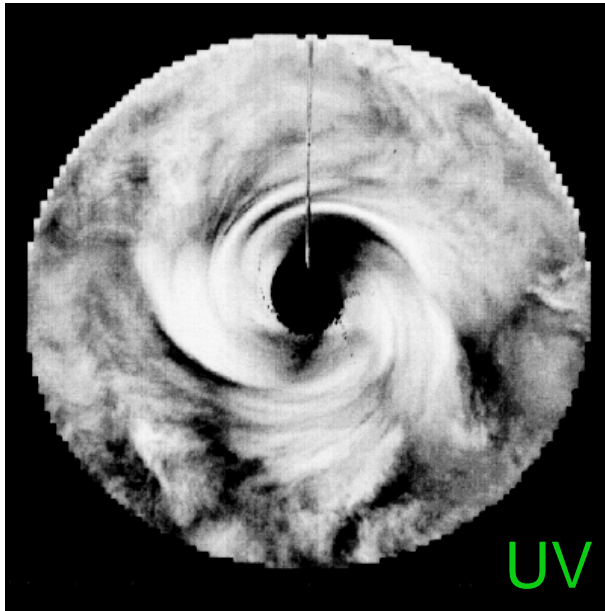


Pioneer Venus OIR Temperatures vs. Height and Latitude

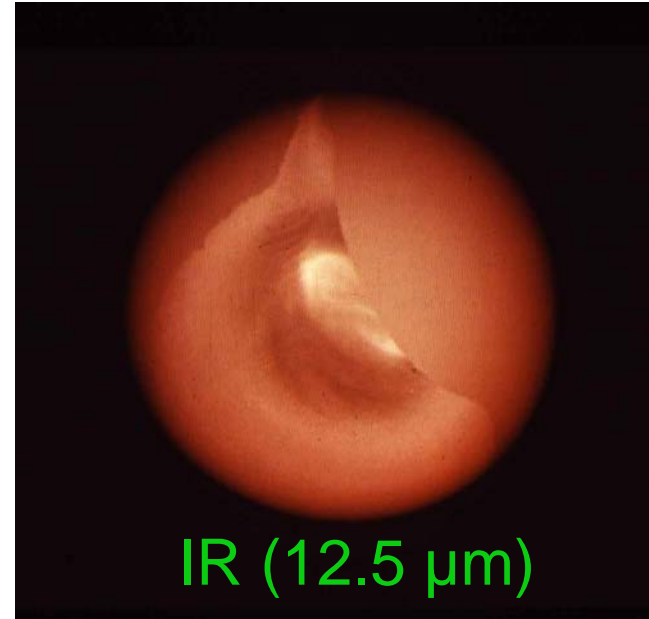


Pioneer Venus OIR Temperatures vs. Height and Latitude

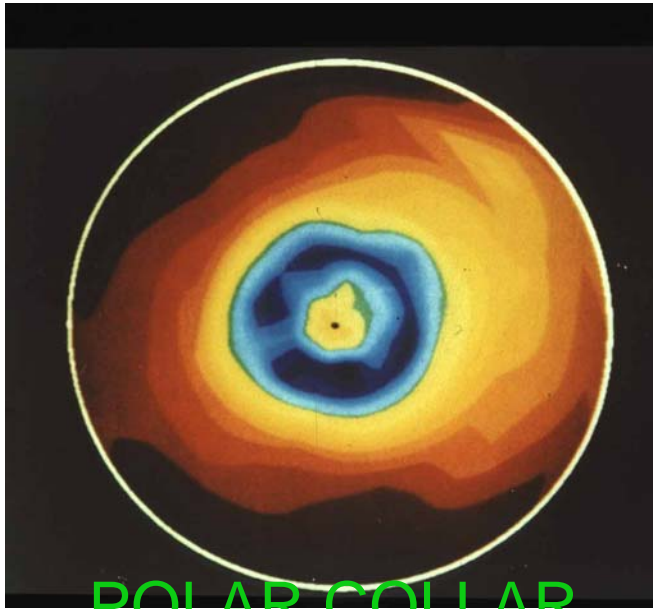




UV



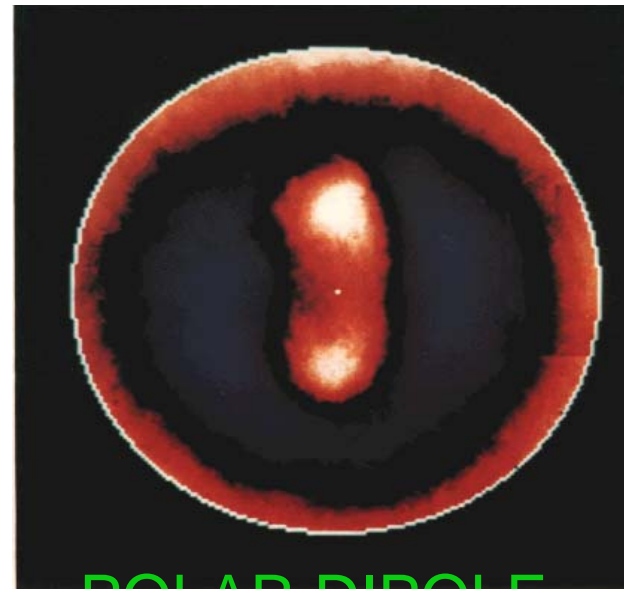
IR (12.5 μm)



POLAR COLLAR

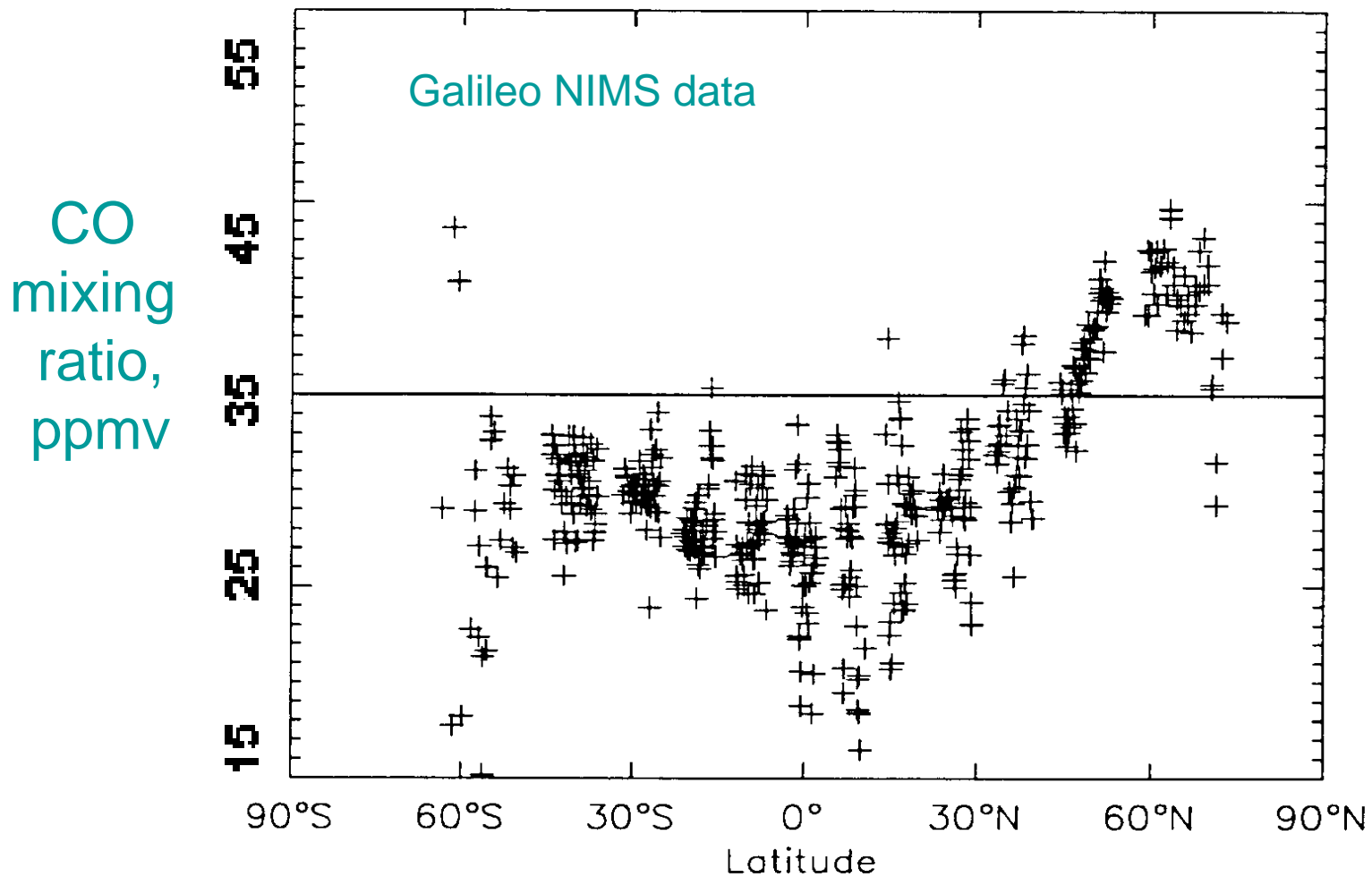
Four
views
of
the
North
Polar
region
of
Venus

(M10 TV,
PV OIR)

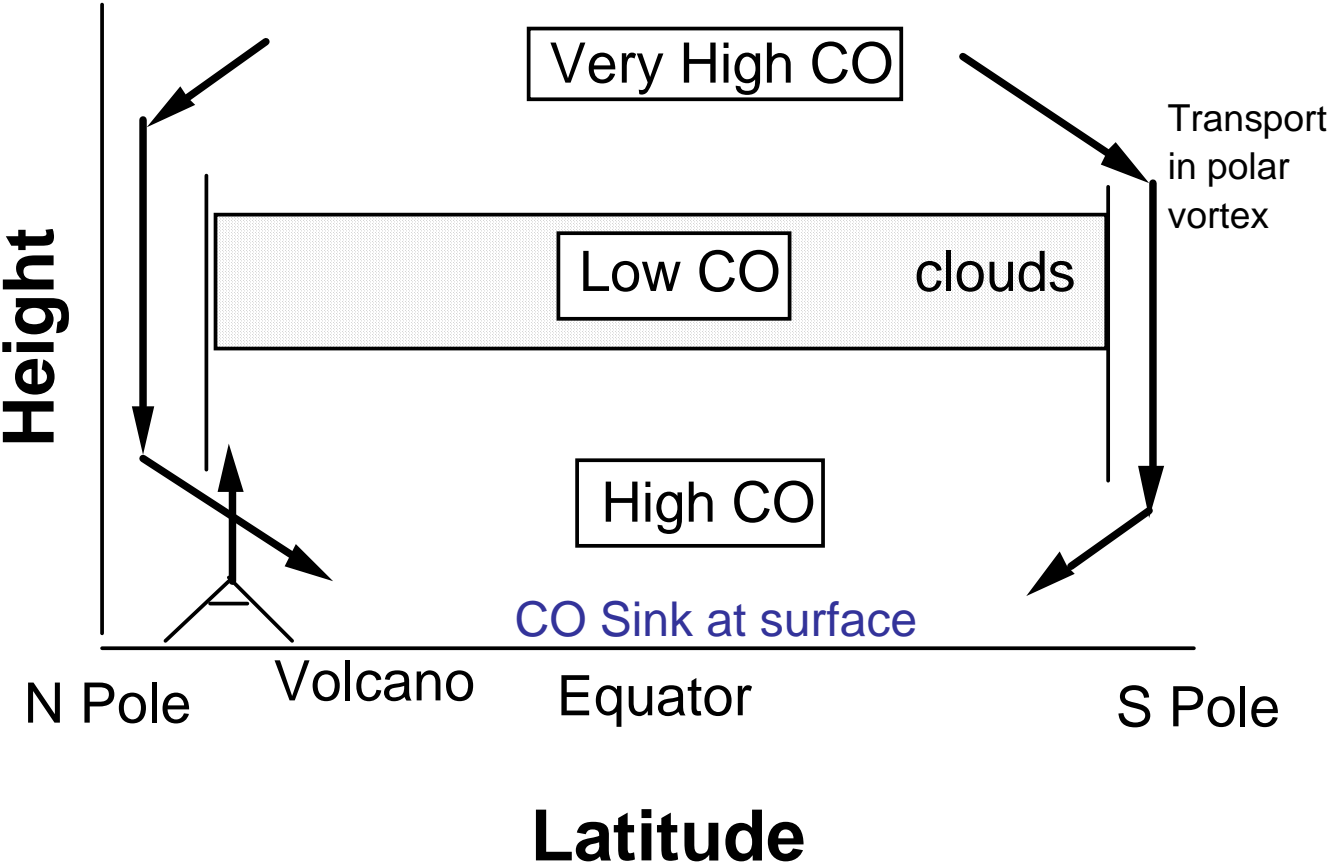


POLAR DIPOLE

The variation with latitude of carbon monoxide abundance near 30 km altitude (Collard et al., 1994).

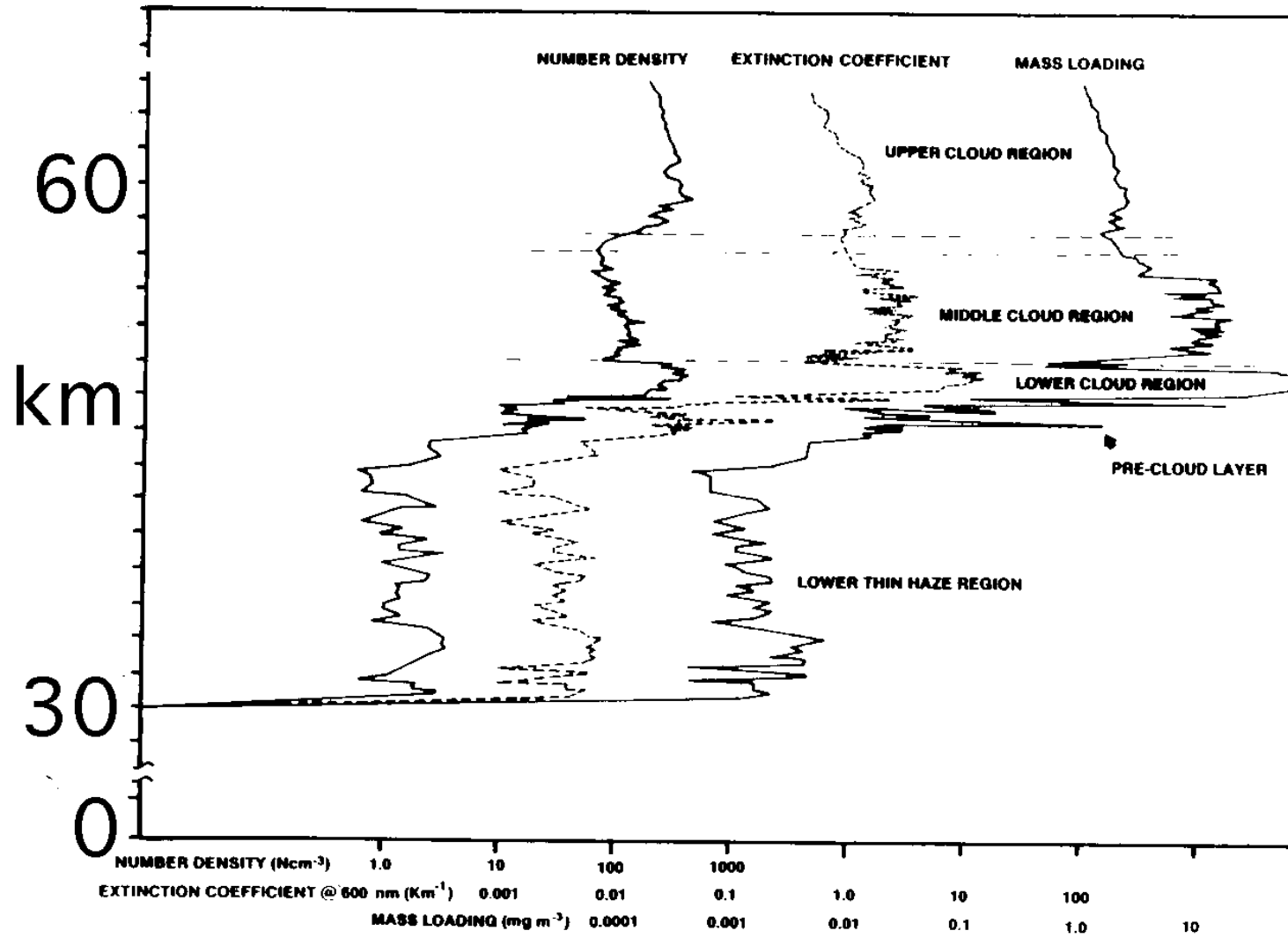


Conceptual model for CO sources on Venus:
transport from the upper atmosphere via the polar vortices.

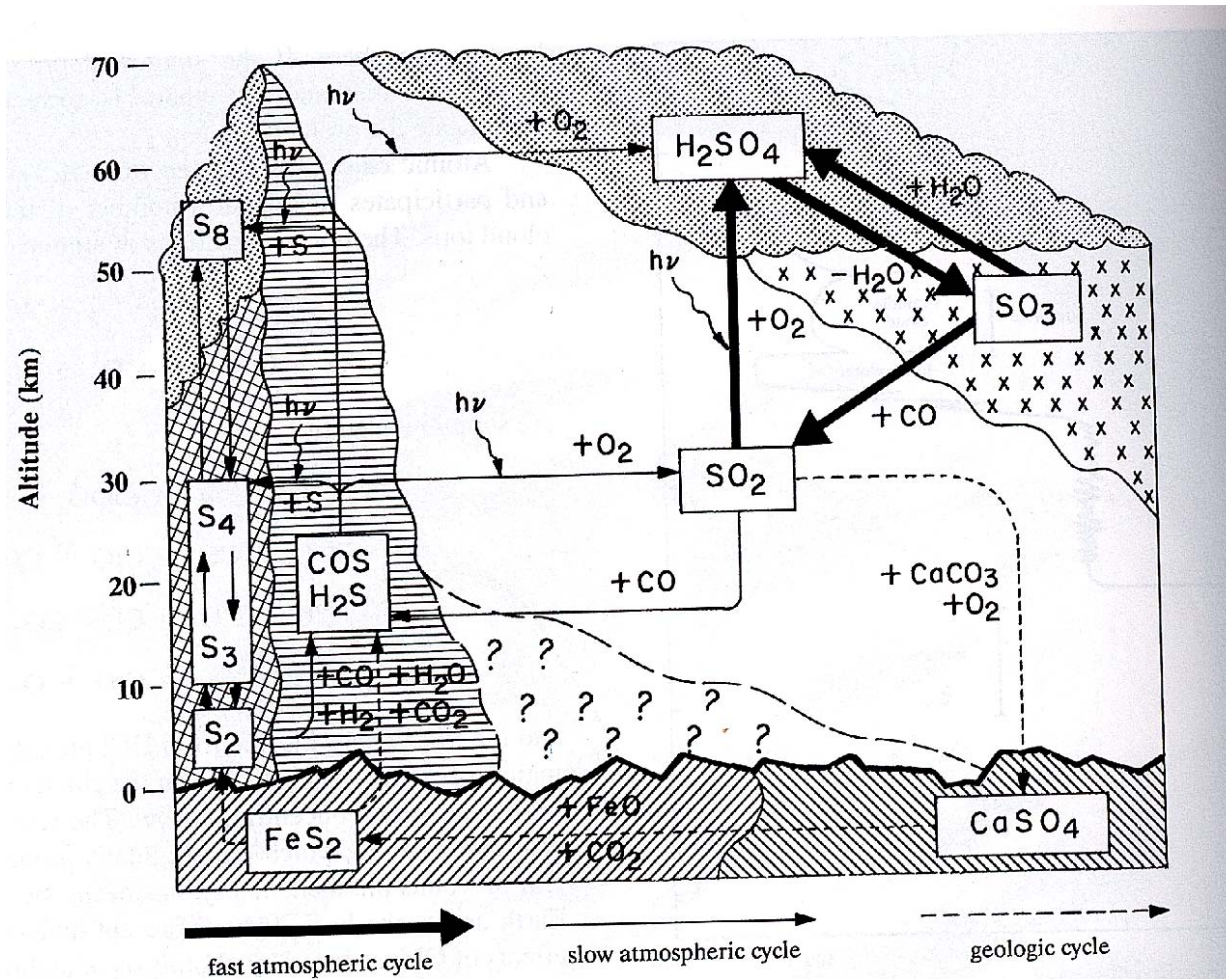


Profile of the clouds from the PV large probe

(RG Knollenberg and DM Hunten, 1980)



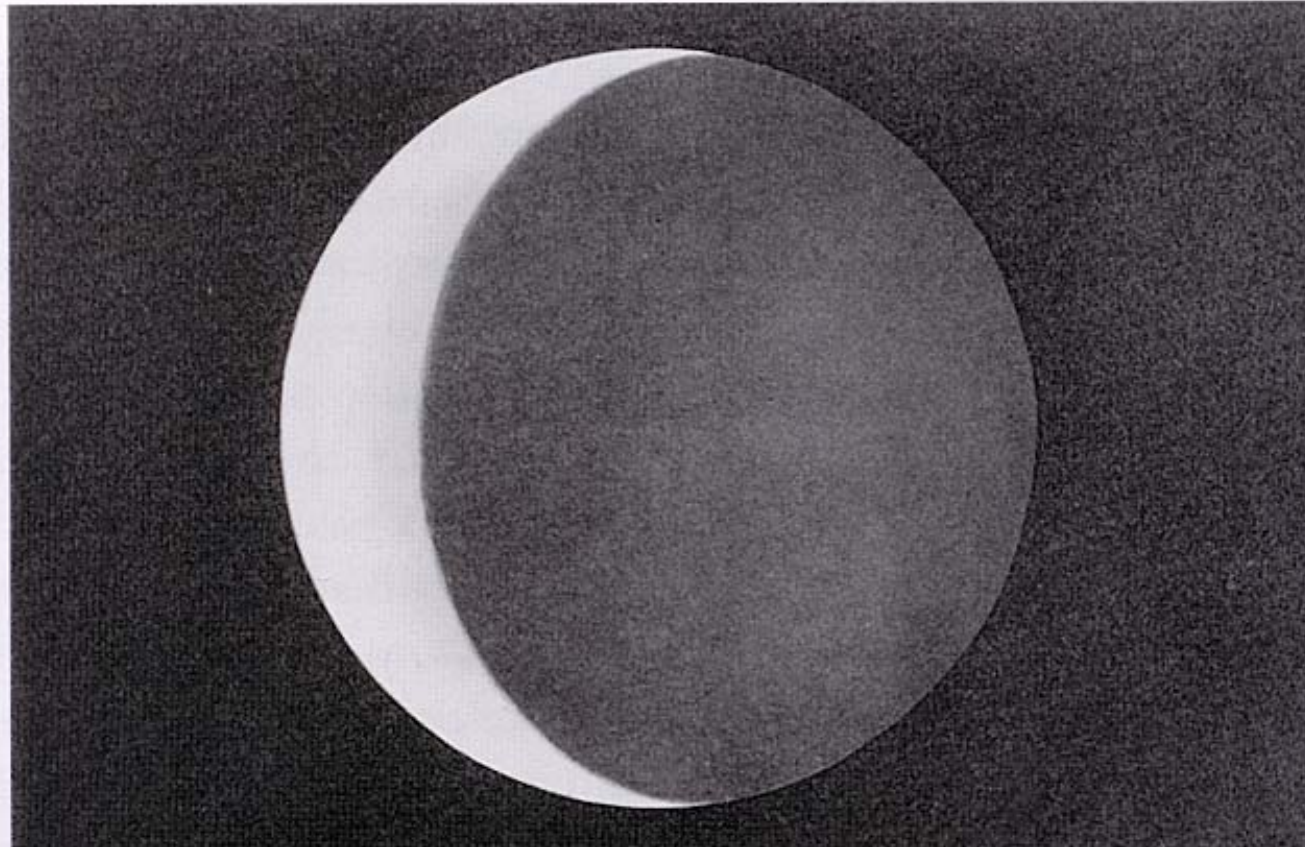
Atmospheric Chemistry dominated by Sulfur?



From 'Physics and Chemistry of the Solar System' by John S. Lewis

The 'Ashen Light' of Venus

first observed by Giovanni Riccioli on January 9, 1643



[P. Moore]

... at 2.3 microns

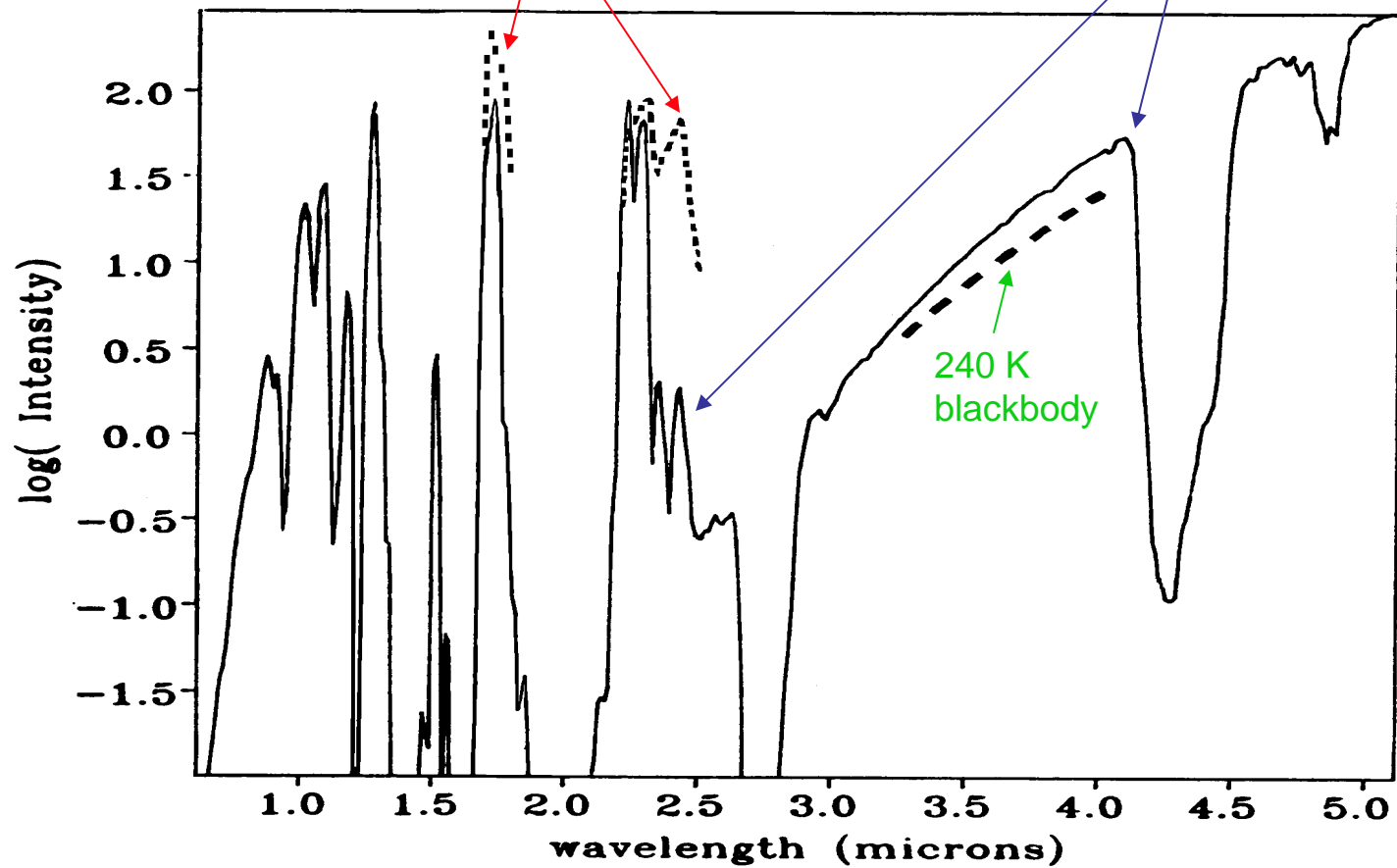


D. Crisp, NASA/JPL

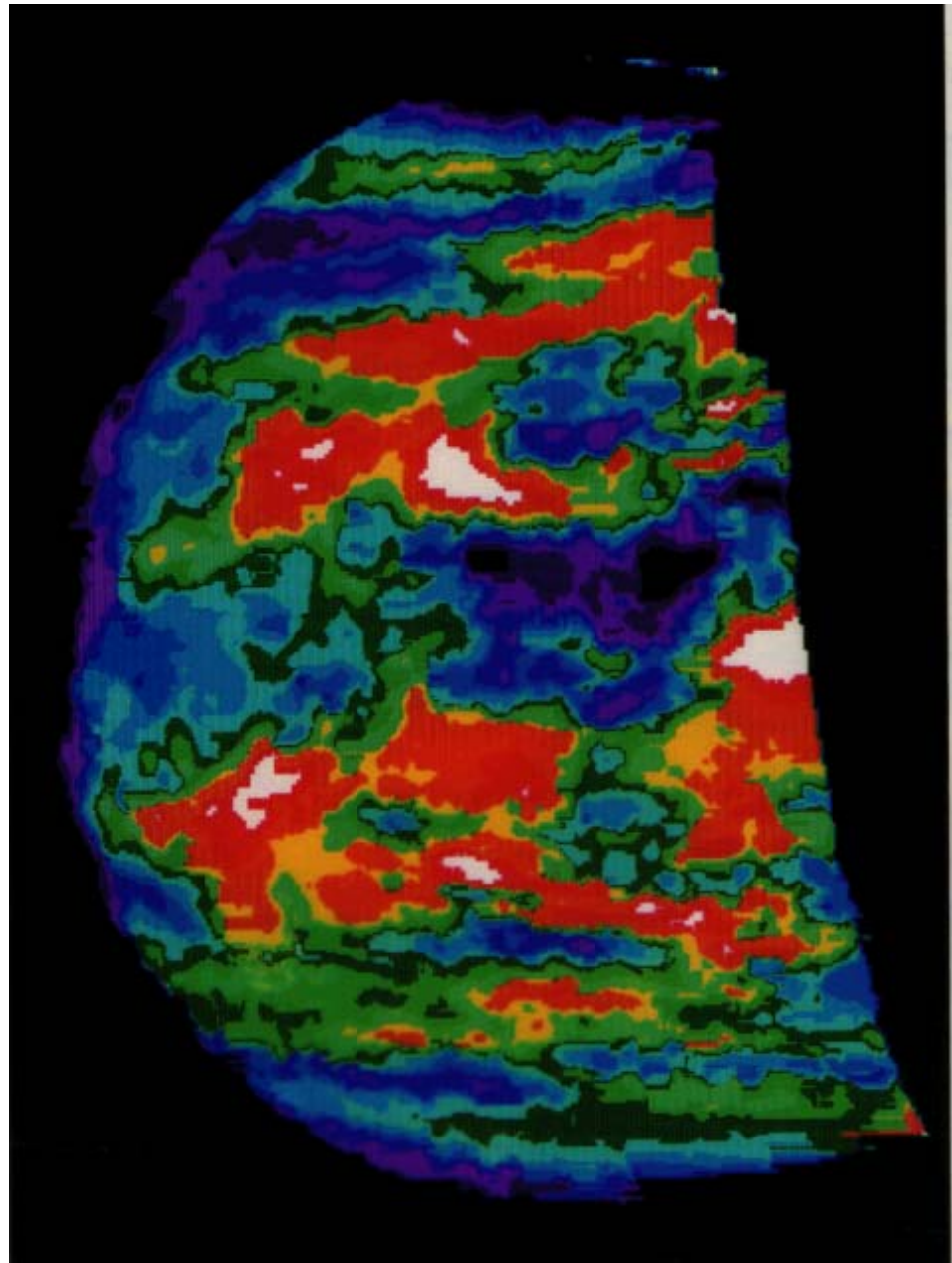
Venus Near-IR Spectrum

Observations (Allen and Crawford, 1984)

Model (Kamp, Taylor & Calcutt, 1988)



Galileo NIMS
view of
mysterious
'weather' in the
deep atmosphere
of Venus
(Carlson et al.)



Energy Balance of the Earth

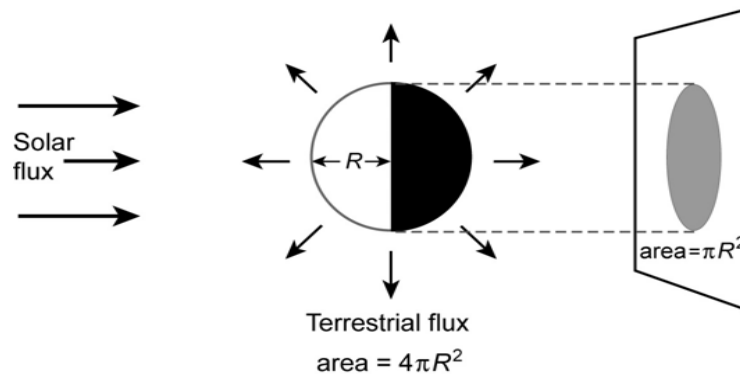
Applying the Stefan-Boltzmann law we obtain for the total radiant power of the Sun, with temperature T_S & radius R_S :

$$E_{Sun} = 4\pi R_S^2 \sigma(T_S)^4 = 4\pi S R_{ES}^2$$

where S is the solar constant and R_{ES} the distance Earth –Sun. Now:

$$E_E = 4\pi \sigma R_E^2 (T_E)^4 = (1-A) S \pi R_E^2$$

→ *radiometric temperature* of the Earth $T_E = 255$ K.



The mean *surface* temperature of the Earth is about 288 K.

The difference is due to the fact that only a small part of the thermal emission to space takes place from the surface; most is from the colder regions near the tropopause.

Energy Balance of Venus

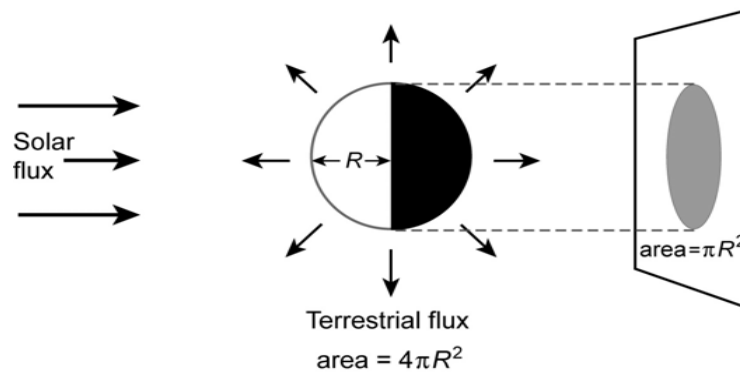
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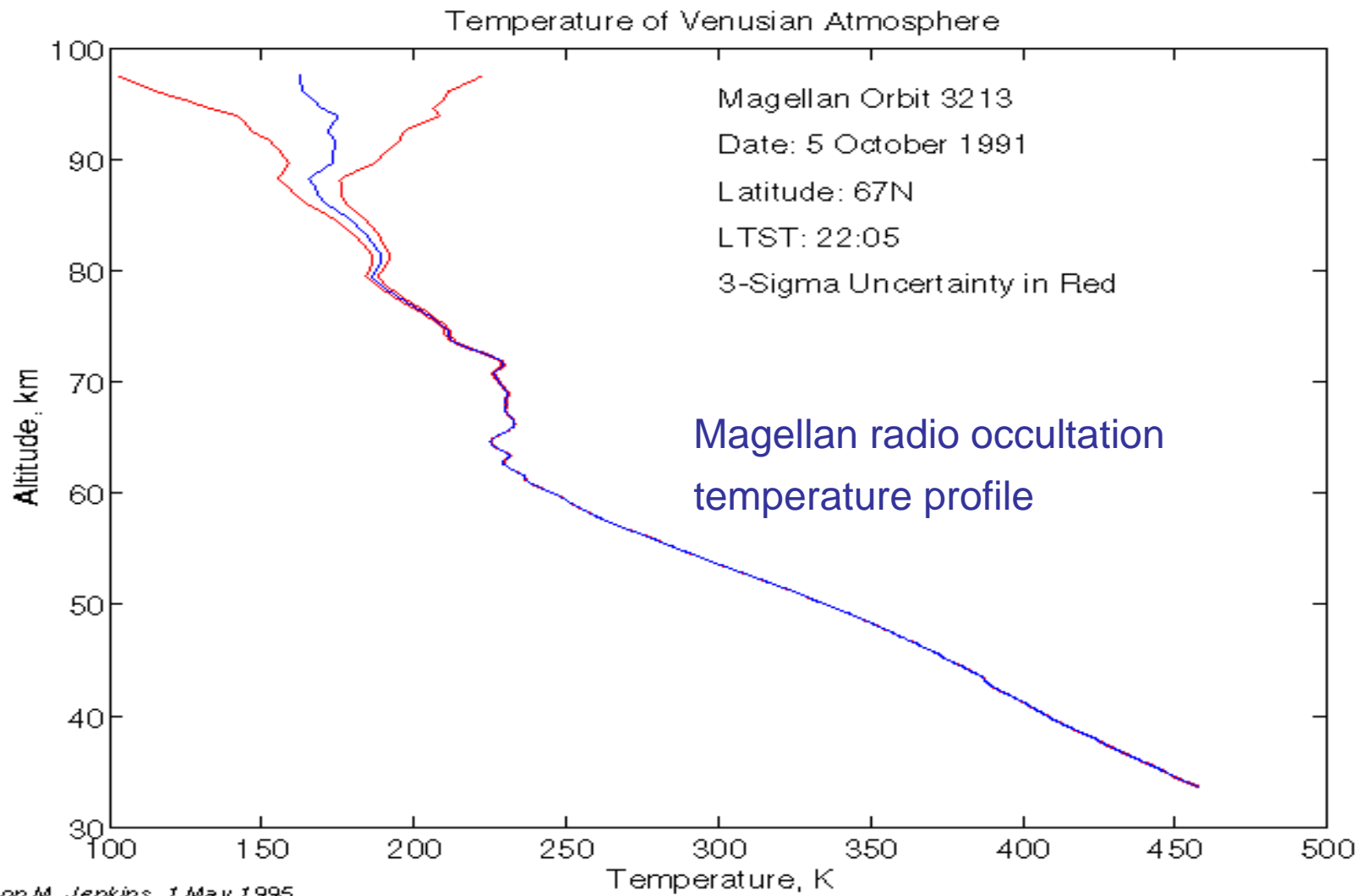
$$E_V = 4\pi \sigma R_V^2 (T_V)^4 = (1-A) S \pi R_V^2$$

→ radiometric temperature of Venus $T_V = 240$ K.



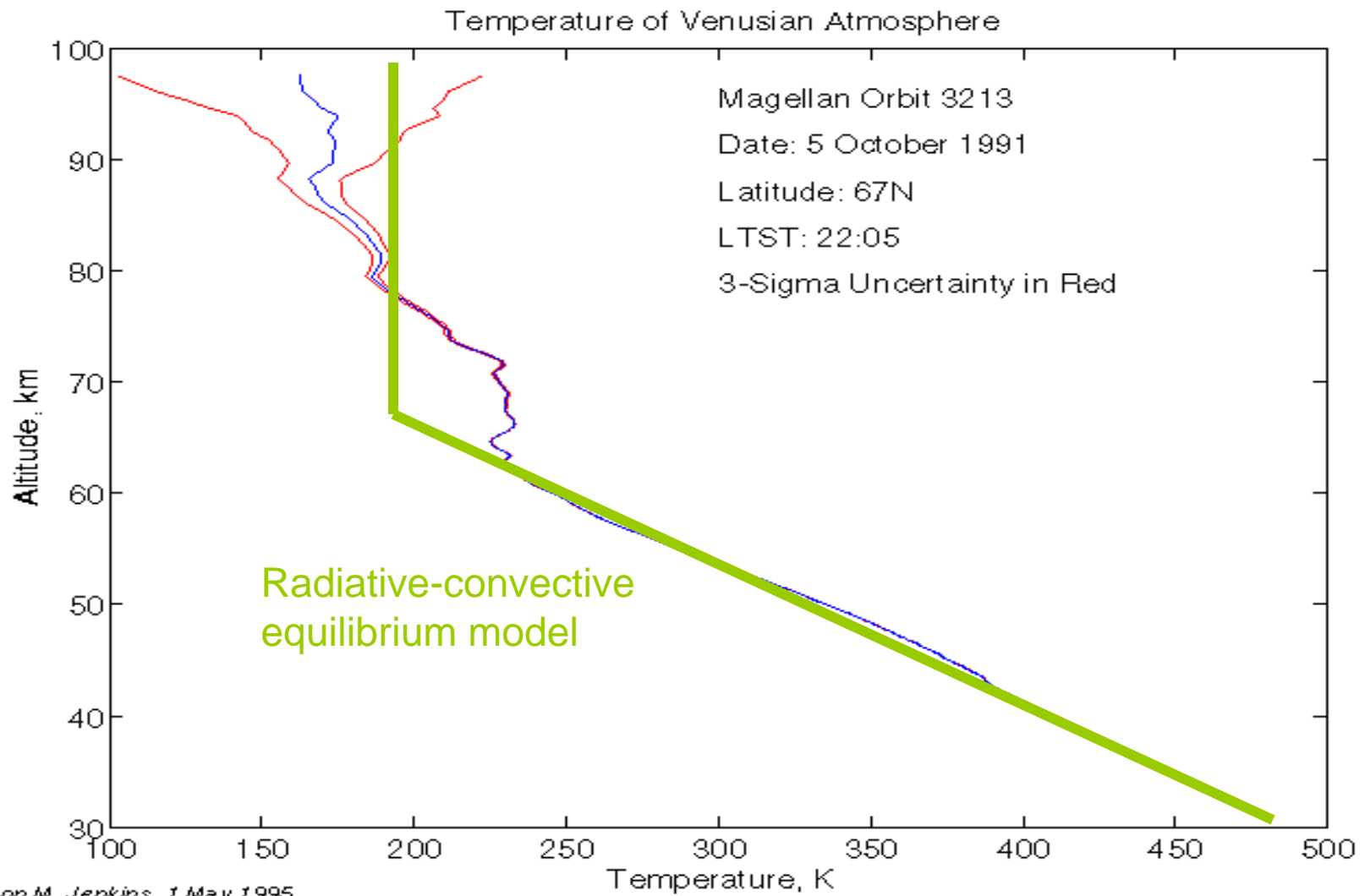
The mean *surface* temperature of Venus is about 760 K.

The difference is due to the fact that only a small part of the thermal emission to space takes place from the surface; most is from the colder regions near the tropopause.



Jon M. Jenkins 1 May 1995

Jenkins, 1995



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Jenkins, 1995

Why is Venus so hot?

- CO₂ is in equilibrium with carbonates on surface (Urey, 1952)
- the dominant reaction is expected (Bullock & Grinspoon 1996) to be

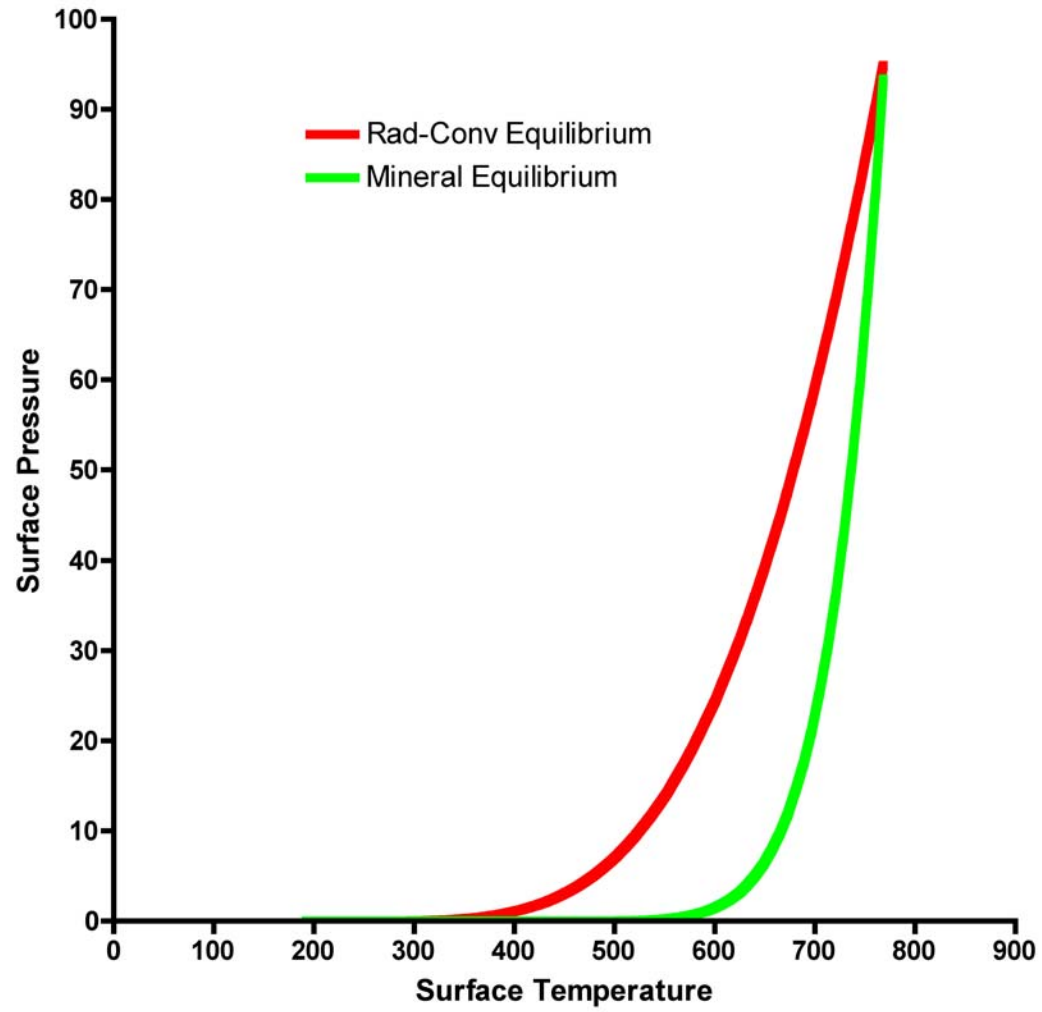


- use thermodynamic data (e.g. Adamik and Draper, 1963) for the temperature dependence of the pressure of CO₂ in the form

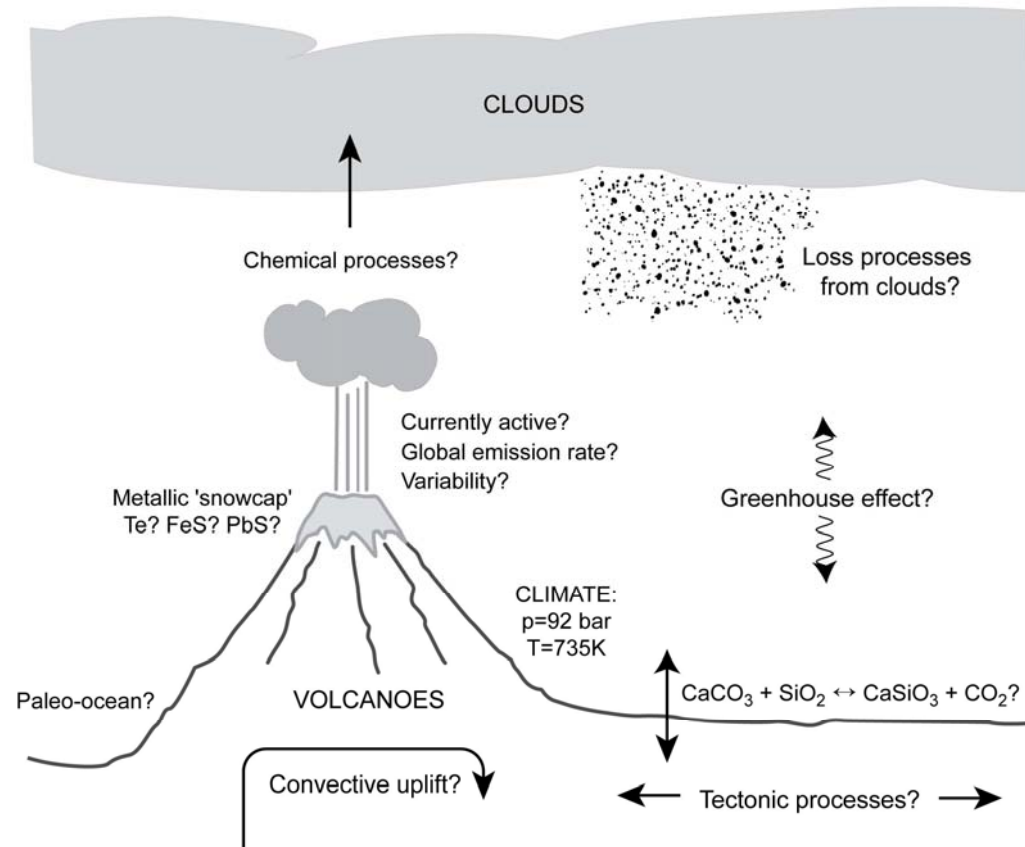
$$\log P = \Delta H/RT + \Delta S/R + A + BT + CT^{-2}$$

- use the radiative-convective equilibrium model for the surface pressure as a function of surface temperature

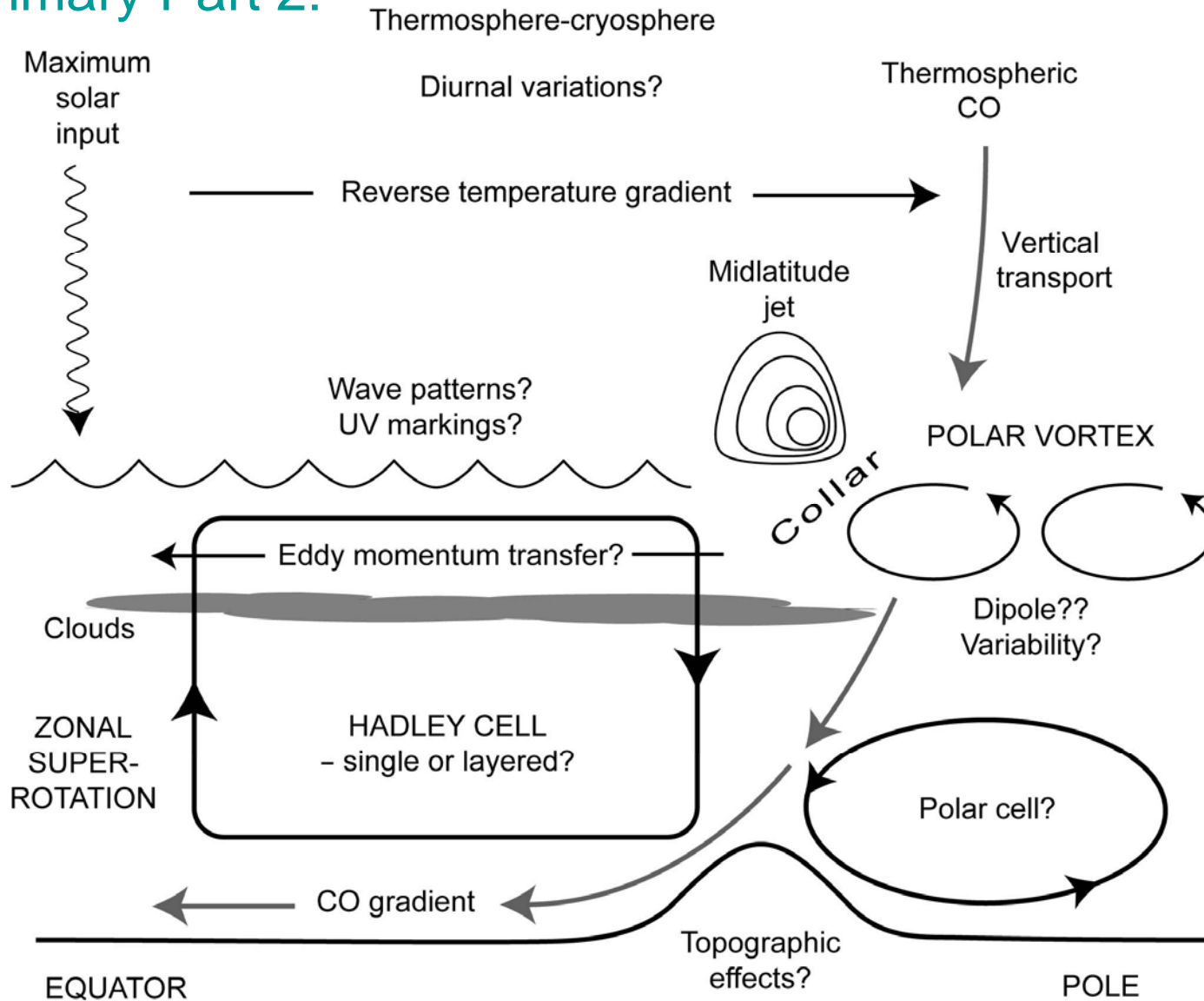
Venus Climate



Summary Part 1:



Summary Part 2:



QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

More data! More data! From pole to equator!
Measure everything, everywhere, all of the time!