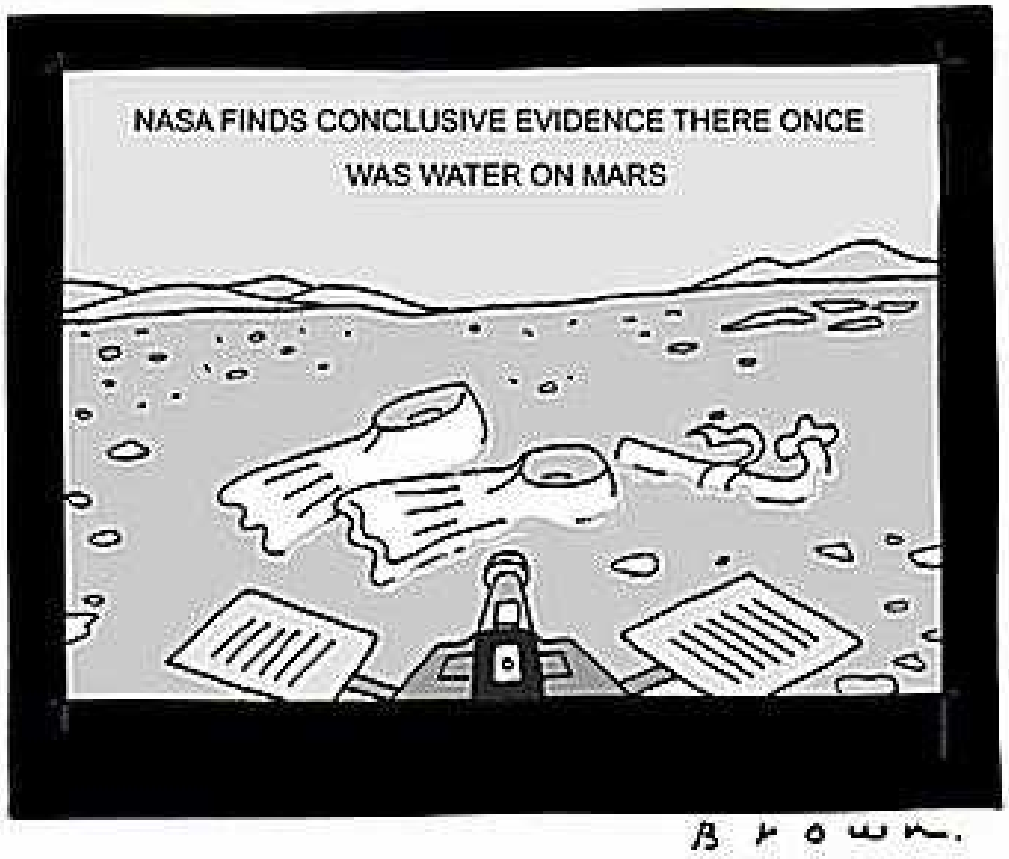
ASTR 380
Possibilities for Life in the Inner Solar System



ASTR 380
Midterm Test Results

Generally people did well:

100 - 90 = A = 19 people
89 – 80 = B = 19 people
79 – 70 = C = 9 people
69 – 60 = D = 0
< 60 = F = 1 person

For total course so far… estimate from homework (30%) and mid-term exam (70%):

100 - 90 = A = 14 people
89 – 80 = B = 24 people
79 – 70 = C = 6 people
69 – 60 = D = 3 people
< 60 = F = 3 person

Possibilities for Life in the Inner Solar System

Last Lecture: the Moon, Mercury and the Moons of Mars.

Now we will look at Venus (this lecture) and Mars (next)
Chapter 7 and Chapter 10.2

Remember: We have only visited the Moon with people.
We only have rocks from the Moon to study on Earth!

We are examining the possibilities in these next few lectures.

- Seeing what existing evidence says
- What we can infer
- Few 100% conclusions

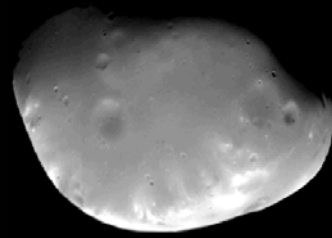
Possibility of Life in the Inner Solar System

The Moon, Mercury, and the Moons of Mars

Moon

Mercury

Deimos



Phobos

NO LIFE NOW or EVER
This is a 98% conclusion!

Possibility of Life in the Inner Solar System

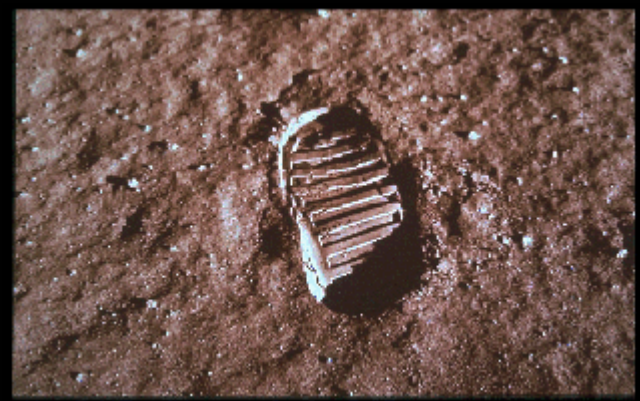
The Moon versus our checklist:

chemical building blocks: light on amounts of C, N, and O

energy: lots of sunlight

liquid: No. And no atmosphere

stability: Except near poles, 29 day day-night cycle
average day temperature = 107 C
average night temperature = -153 C



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The Mercury versus our checklist:

chemical building blocks: 70% metallic and 30% silicate
may have lost much C, N, O in a late large collision.

energy: lots and lots of sunlight

liquid: No. Nearly no atmosphere

stability: Due to 59 day long rotation (Mercury day) and very slight atmosphere…
night time lows = -183 C
daytime highs = 427 C

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The Moons of Mars versus our checklist:

chemical building blocks: Carbonaceous asteroids so good C,N,O

energy: reasonable sunlight

liquid: No. No ices. No atmosphere

stability: Probably reasonable but no data on temperature variations as specific locations on Moons

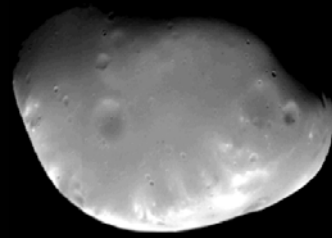
Possibility of Life in the Inner Solar System

The Moon, Mercury, and the Moons of Mars

Moon

Mercury

Deimos



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Possibility of Life in the Inner Solar System

What do we know about Venus?

Cloud covered at all times!

Mass = 0.815 Earth mass

Surface Gravity = 0.91 Earth

Average Density = 5.25 g/cm³

Distance from Sun = 0.723 AU

Physical Data — **For comparison**

Property	Venus	Earth	Mars
Distance from the Sun	108 million km	150 million km	228 million km
Rotation period	243 days	24 hours	24.37 hours
Equatorial radius	6052 km	6378 km	3379 km
Mass	4.87×10^{24} kg	5.97×10^{24} kg	6.42×10^{23} kg
Density	5240 kg/m³	5520 kg/m³	3940 kg/m³

02-2004

Possibility of Life in the Inner Solar System

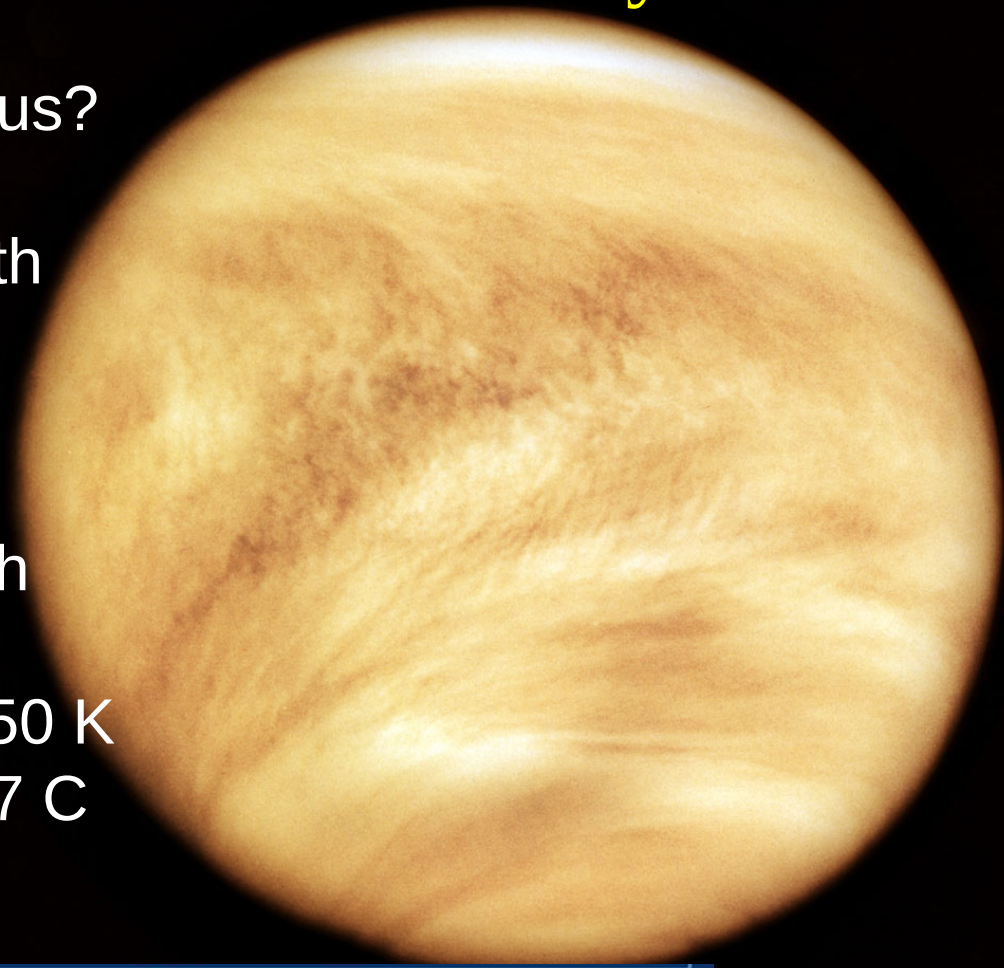
What do we know about Venus?

Energy from Sun = 1.9 x Earth

No Moons

Equatorial radius = 0.95 Earth

“Expected Temperature” = 350 K
= 77 C



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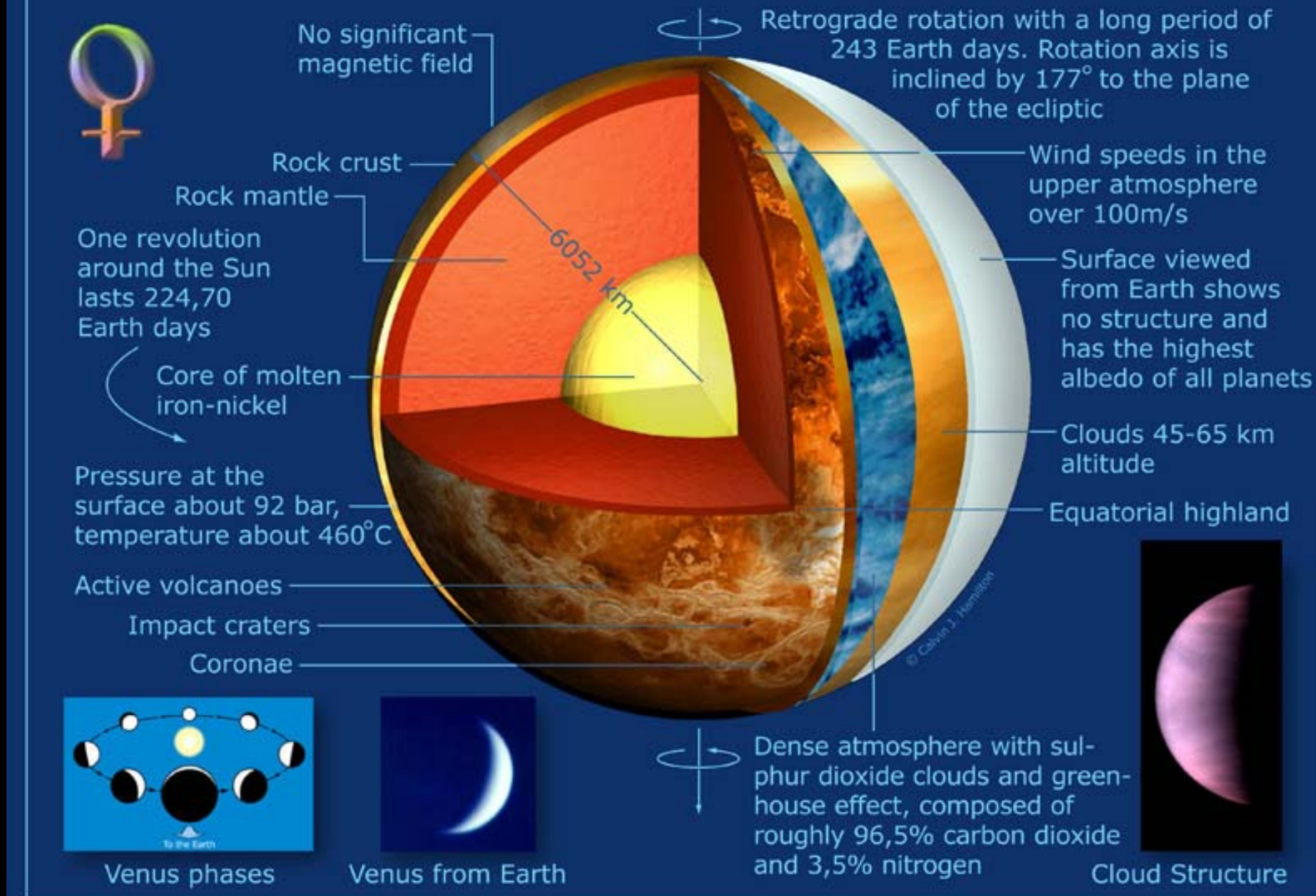

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Venus has been visited by probes:

Mariner 2 flyby in 1962
- measured surface temperature
- tried to measure magnetic field

Venera 3 crashed into planet in 1966
- no data returned

Venera 4 entered atmosphere in 1967 and parachuted down but died before getting to the ground.
- measured composition of atmosphere and pressure

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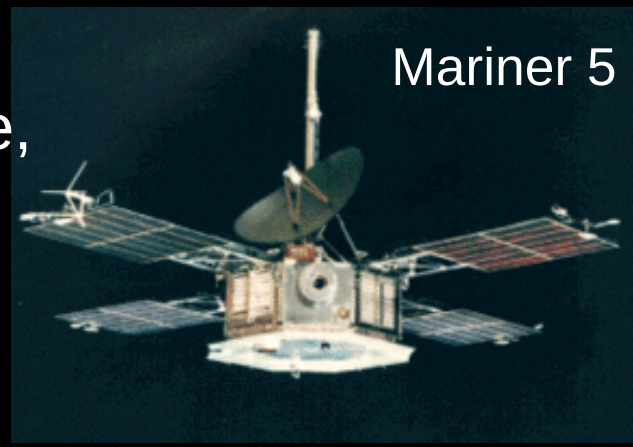
Mariner 5 fly by a 4,000 km above atmosphere in 1967

- Measured pressure profile of atmosphere


Mariner 5

Venera 5 and 6 (1969) entered atmosphere, descended and were crushed about 20 km above surface

- returned more atmospheric data

Venera 7 (1970) supplied temperature data from the surface for 23 minutes.

Venera 8 (1972) send surface temperature data for 50 minutes.

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Mariner 10 (1974) flyby with images of clouds.

Venera 9 and 10 (1975) sent back the first images of the surface.

- images
- surface temperature, pressure, wind

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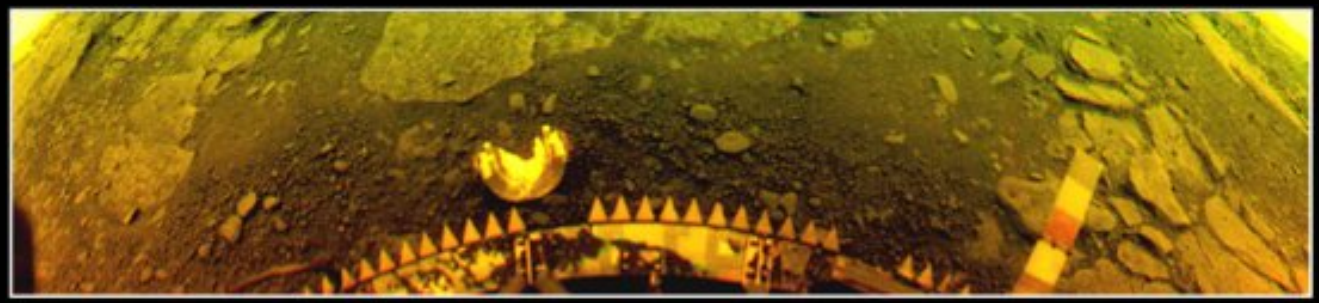
Venera 11 and 12 (1978)

Venera 13 and 14 (1982) made
first color picture of surface



Color as seen on the surface of Venus

Color with atmospheric effects removed

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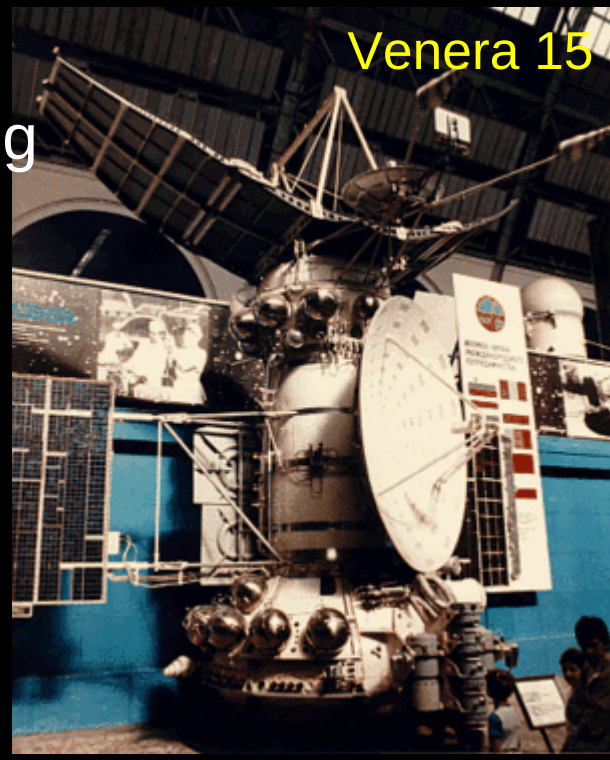
Venera 15

Venera 15 and 16 (1983) did radar mapping of surface from orbit.

Russian Vega Program (1985) put two areobots (balloons) in atmosphere. Second lasted for 2 Earth days.

- Atmosphere temperature, pressure, winds.

Magellan Probe (1990-1994) mapped surface of Venus with radar imaging

Venus Express (European – 2006 to present) imaging the clouds on Venus from Orbit.

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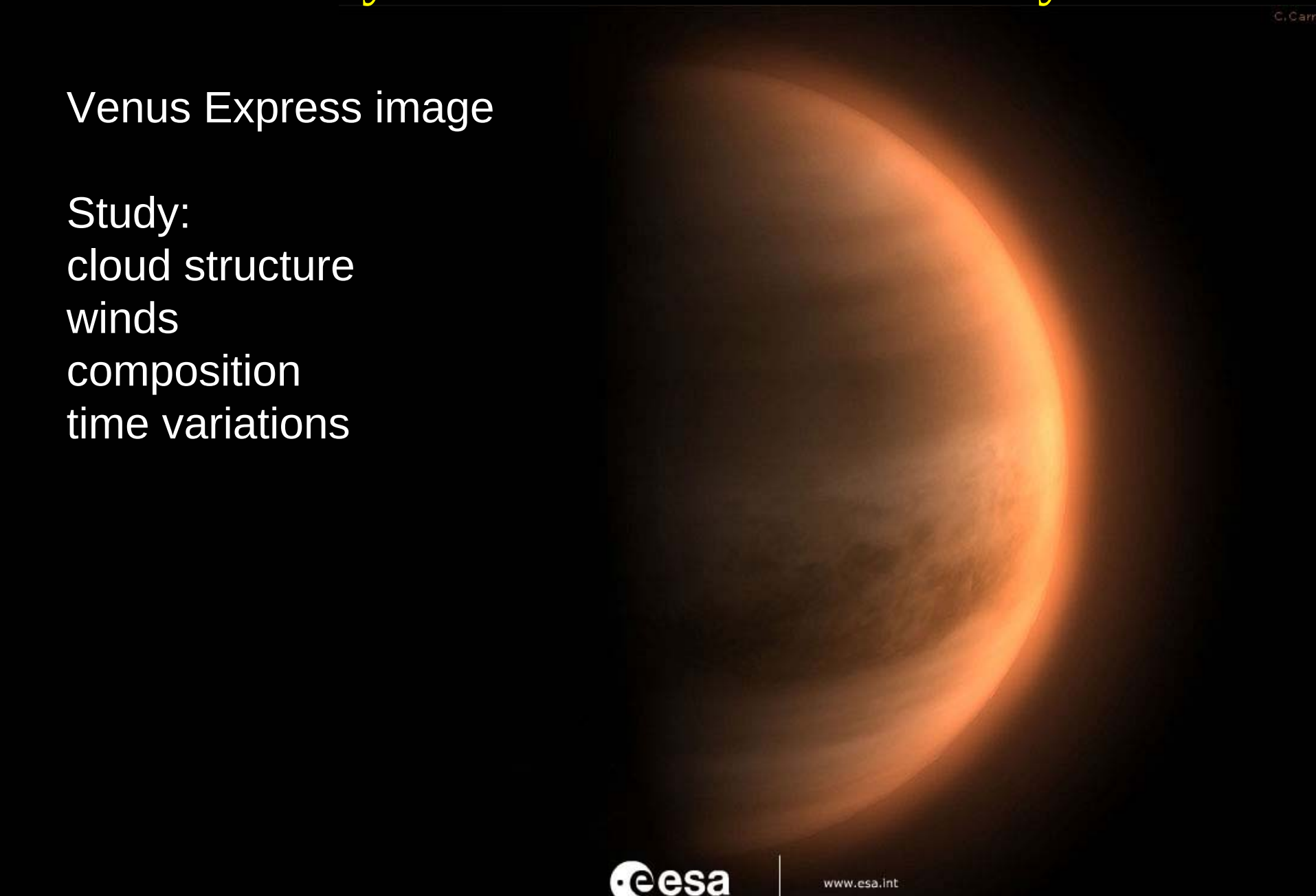
Venus Express image

Study:
cloud structure
winds
composition
time variations



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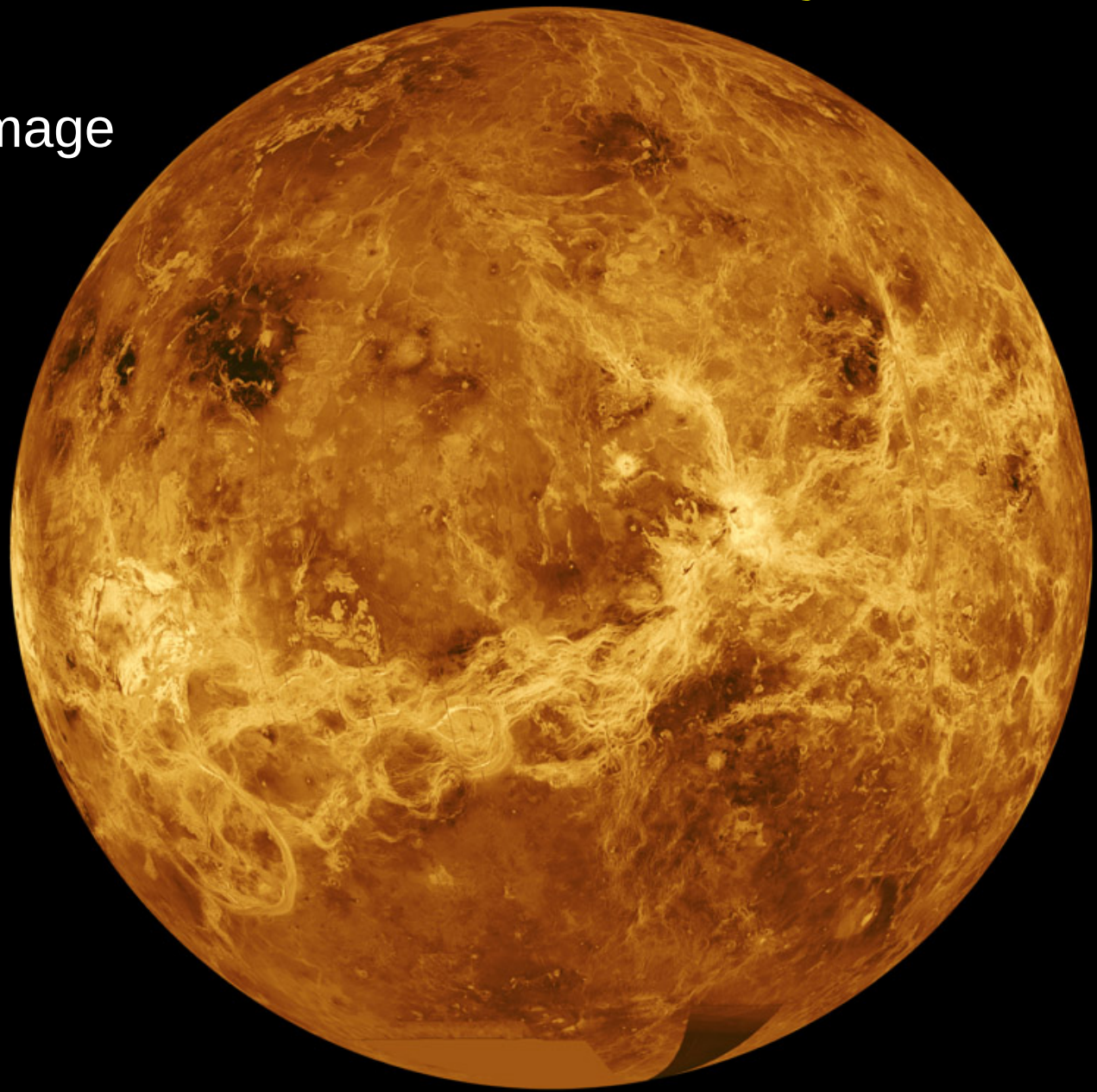
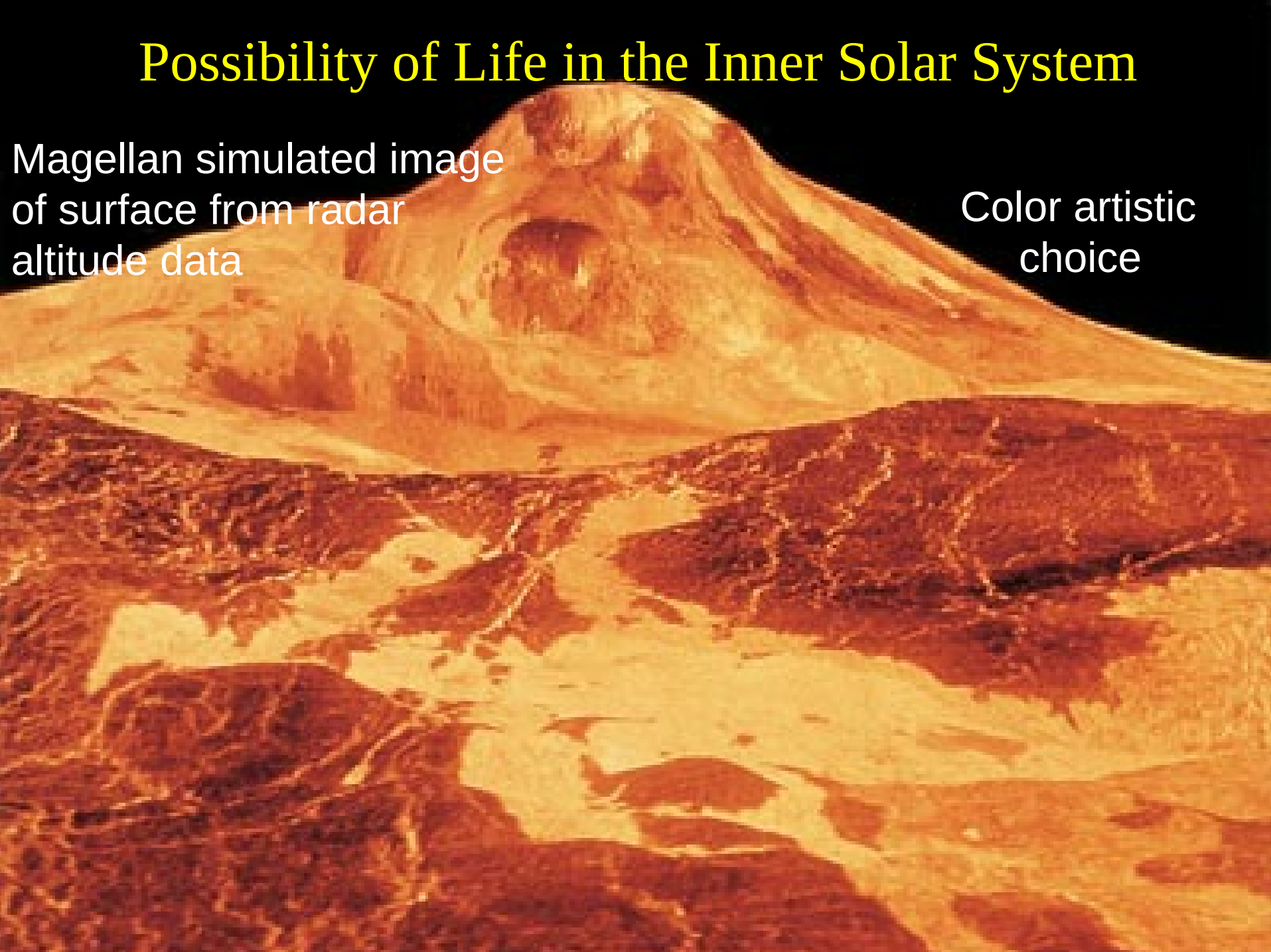
Magellan radar image of the surface of Venus

Radar can see through the clouds to measure the altitude of the land

Light colors are higher altitude.



Possibility of Life in the Inner Solar System



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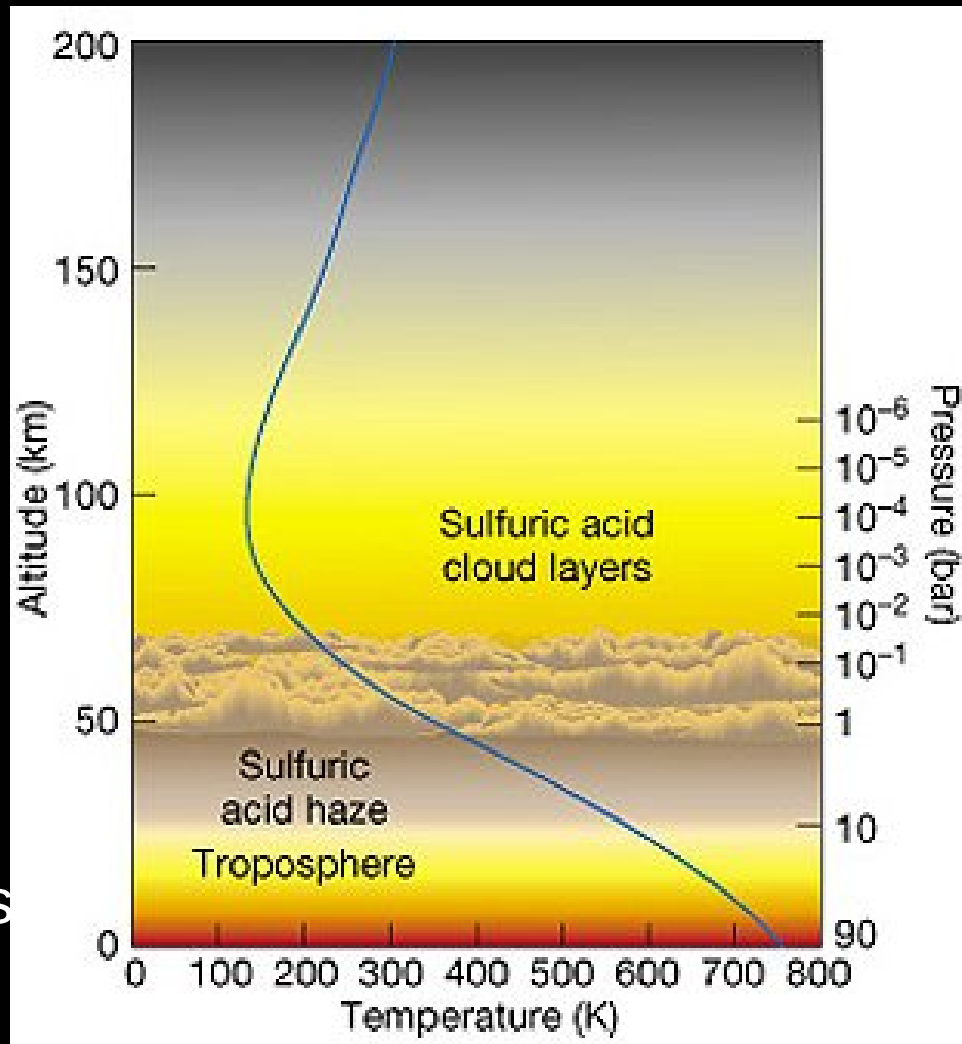
What have we learned from the probes?

- Most of the surface of Venus is covered by old lava flows but there appears to be little current activity.
- There are rocks, mountains, and canyons
- No evidence of liquid water now or in past. No ice
- Impact craters – It is suggested that the surface may be only 500-700 Myrs old
- No plate tectonic activity
- Surface Temperature = 460 C – and nearly constant

Possibility of Life in the Inner Solar System

What have we learned from the probes?

- Surface pressure = 92 bar
  = 92 times Earth
- Composition
  - CO_2: 96.5%
  - N_2: 3.5%
  - SO_2: 0.015%
  - Ar: 0.007%
  - H_2O: 0.002%
  - CO: 0.0017%
  - He: 0.0012%
  - Ne: 0.0007%
- Strong winds and clouds



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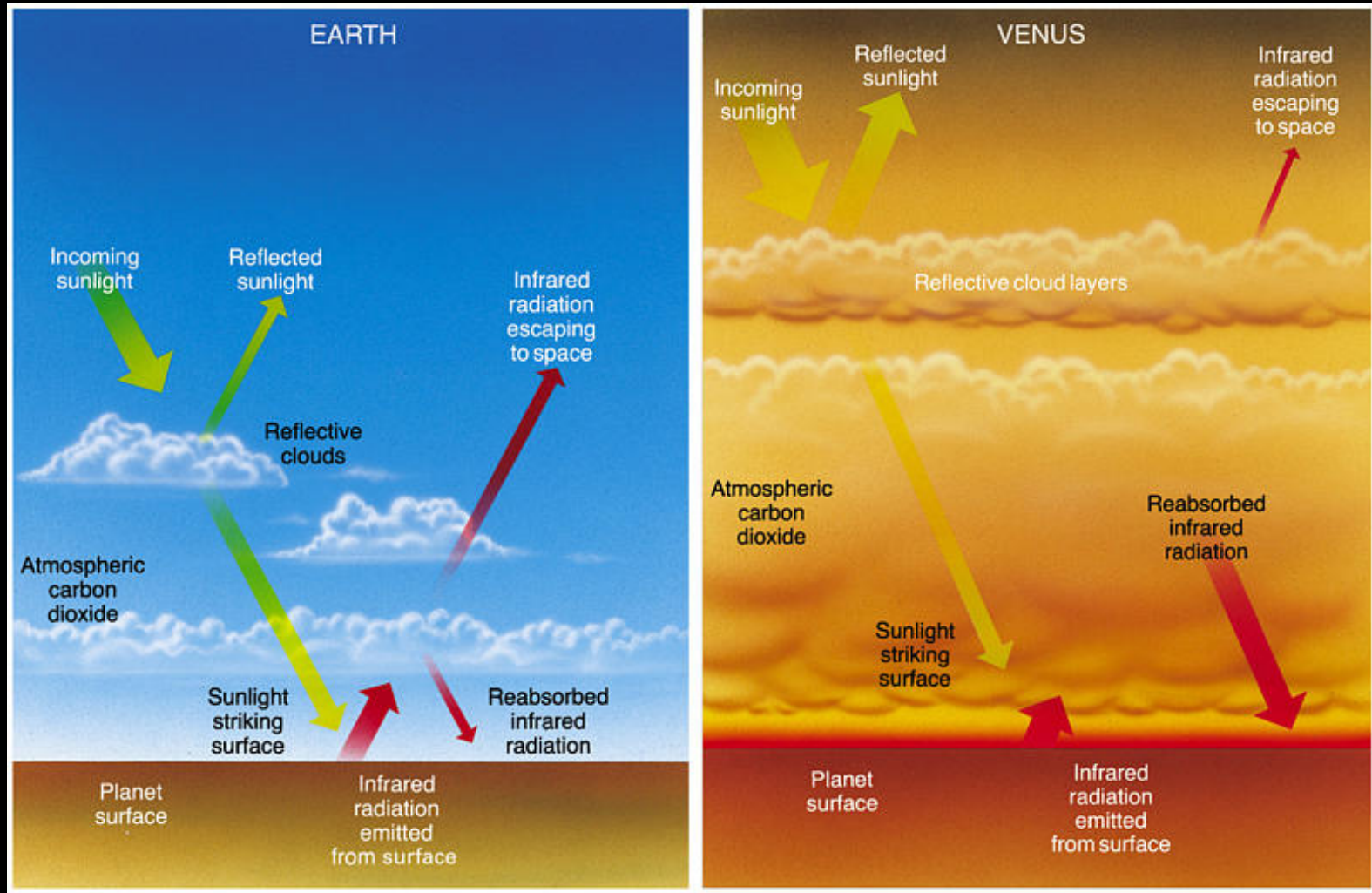
CO_2 and the runaway Greenhouse!
Thick carbon dioxide atmosphere traps the infrared radiation

460 K

versus

350 K



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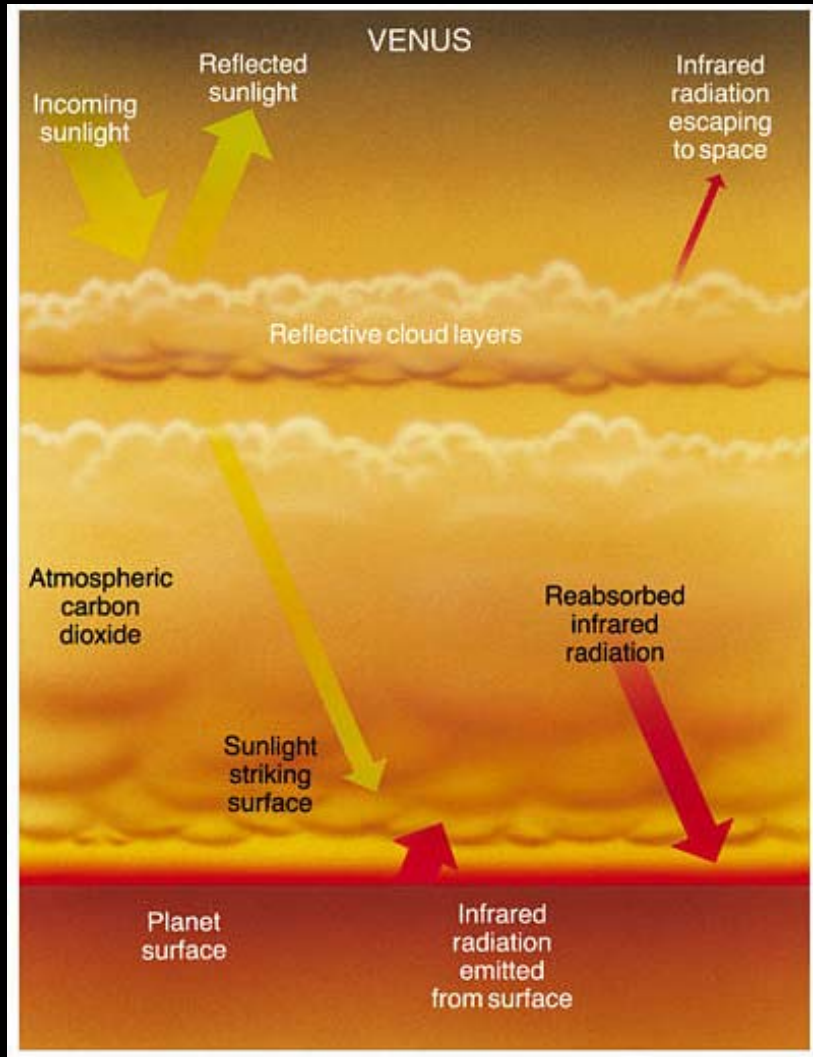
Why is there so much CO_2?

Venus and Earth should have formed in the same way from nearly the same material – should have same rock and gas composition….

But…. Earth had….

The collision that made the Moon -- stripped early Earth atmosphere.

And liquid water -- geological processes to lock CO2 into rocks



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The water problem – Venus is dry, very dry!

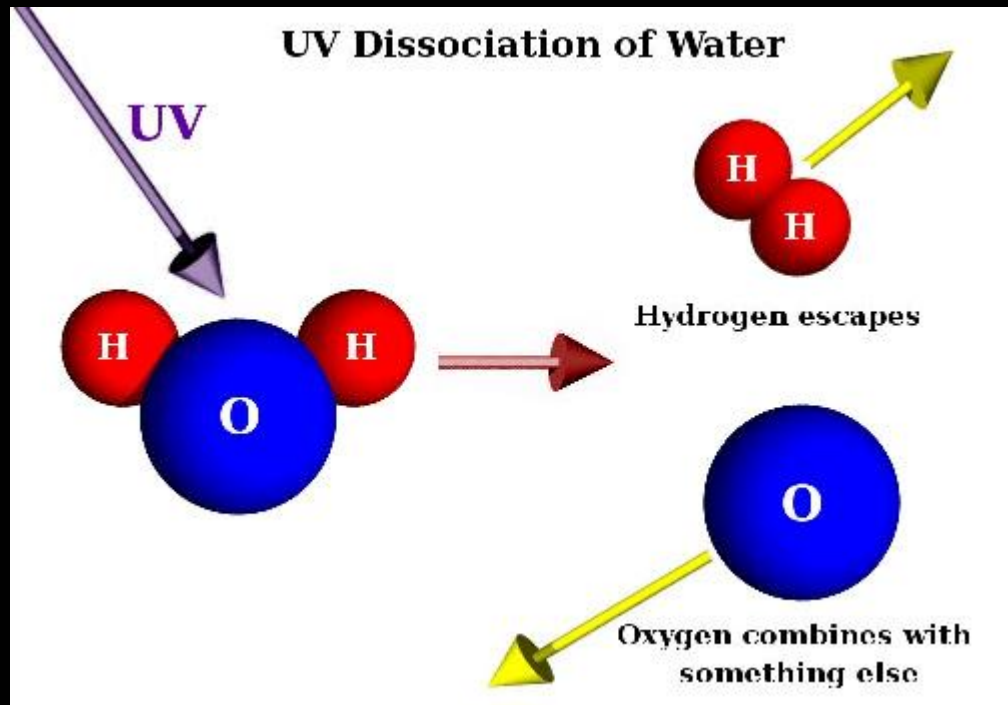
Yes, it is hot so you wouldn't expect liquid water…..

But Venus appears to have 1/10,000 as much water as Earth!

Why? Perhaps….

Water is in water vapor which rises to the top of the atmosphere – is split – and hydrogen escapes…

Factors: hot, close to Sun,
and no magnetic field



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Terra-forming Venus

Problems to solve:

- Too hot
- Too much CO_2
- Too little water?

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What about Venus in the first few 100 Million years?

WARNING: Little known

Sun dimmer by 30% so less energy input – known

If liquid water was present, CO_2 => rocks…

Kept atmosphere thin…. Cooler…. Earth-like?

Then, CO_2 grew too thick,
became too hot for liquid water…
no more CO_2 into rocks….
atmosphere increased … more heat…

Possibility of Life in the Inner Solar System

The Venus versus our checklist:

chemical building blocks: Earth-like origin. Lots of C, N, O. But currently low on water!

energy: reasonable sunlight. Hot temperatures a problem for Earth type complex molecules

liquid: No. Too hot for water

stability: Very hot and dry now. Surface may have episodes of extreme volcanic activity.

Very poor chance for current life.
Small chance of life in the past.