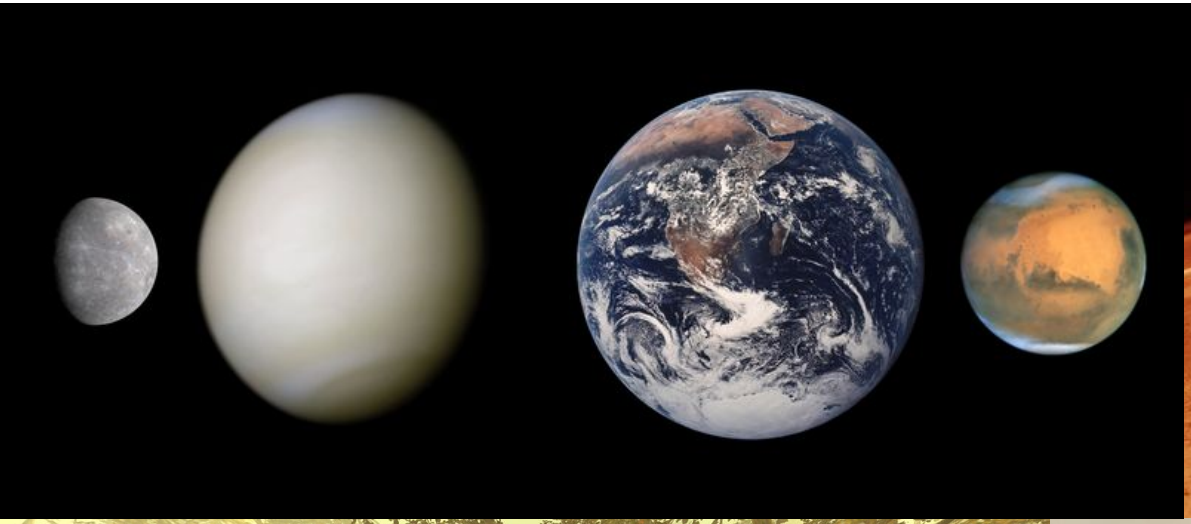
The Search and Prospects for Life in our Solar System



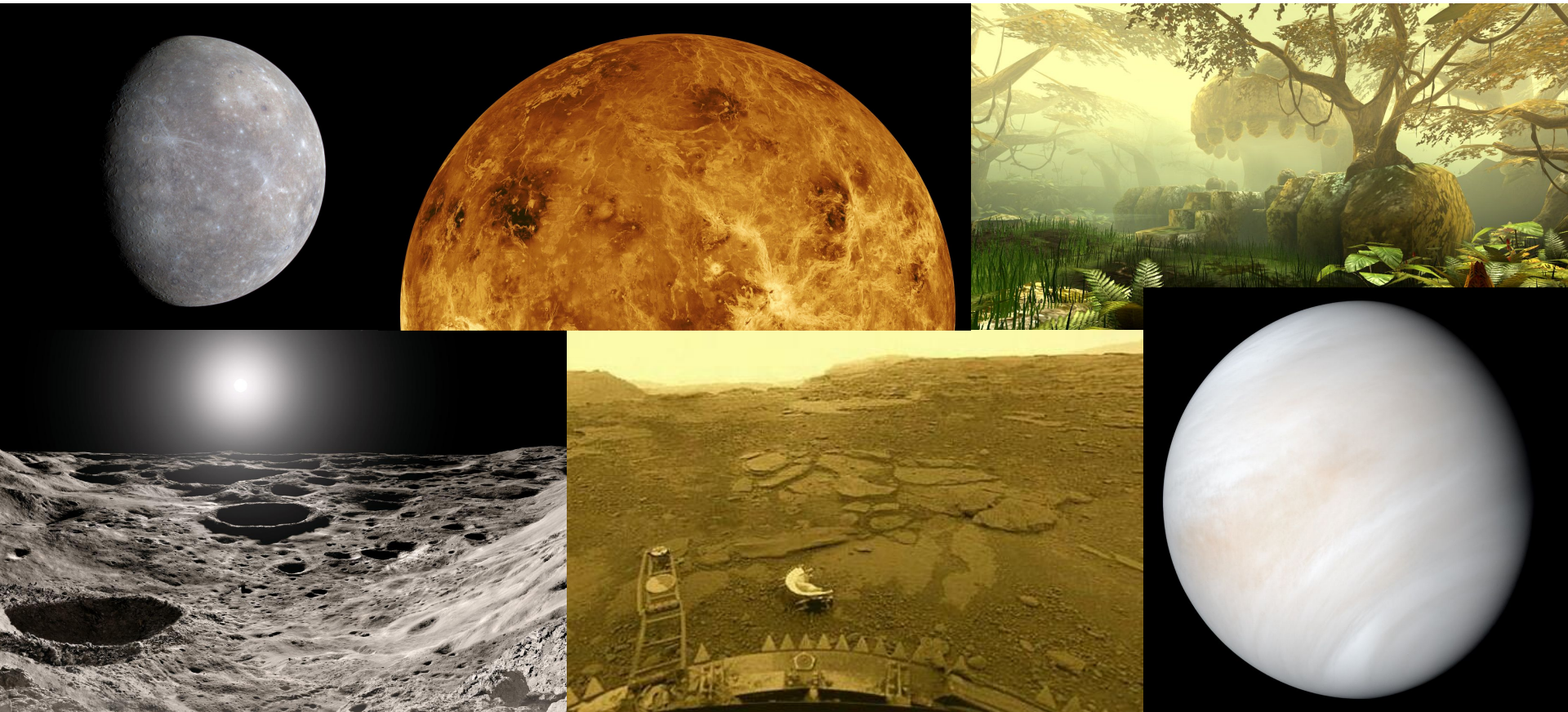




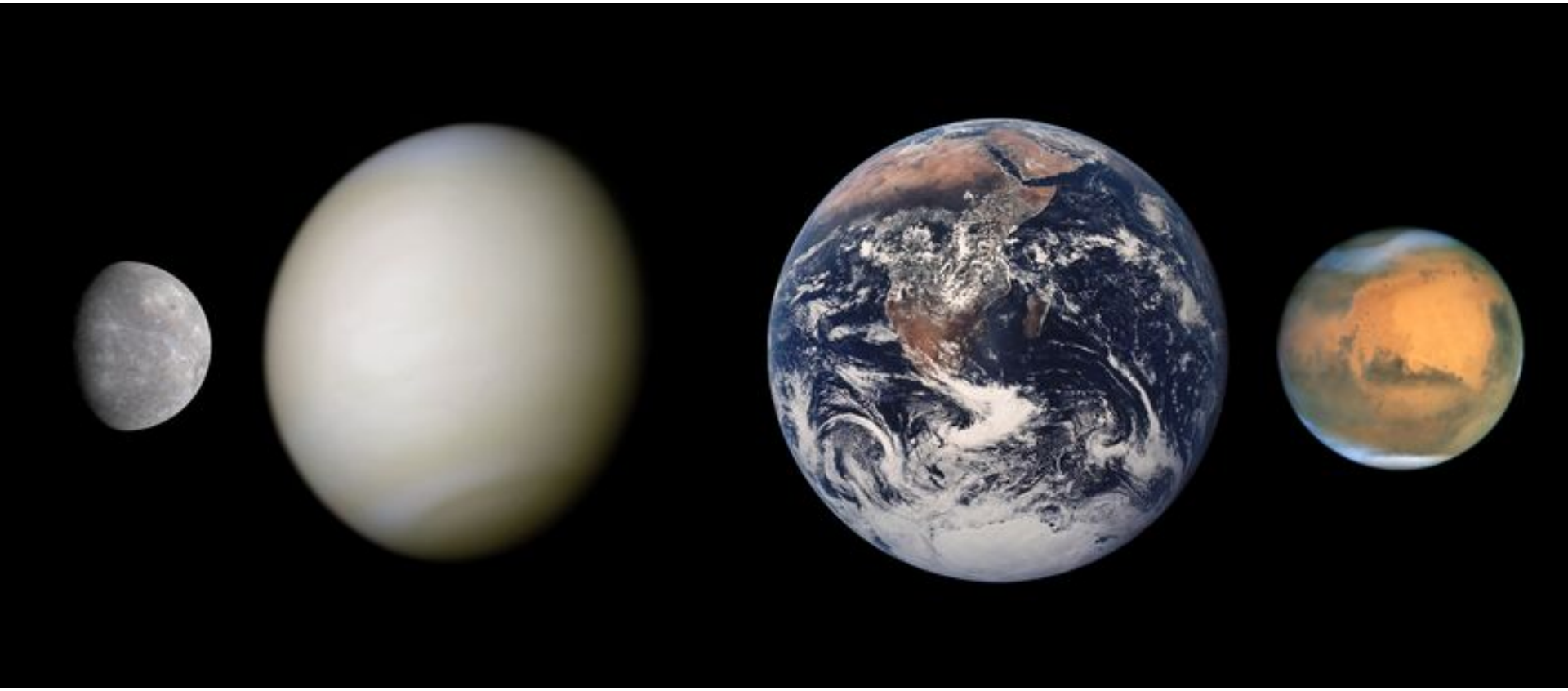


Today's Learning Goals:

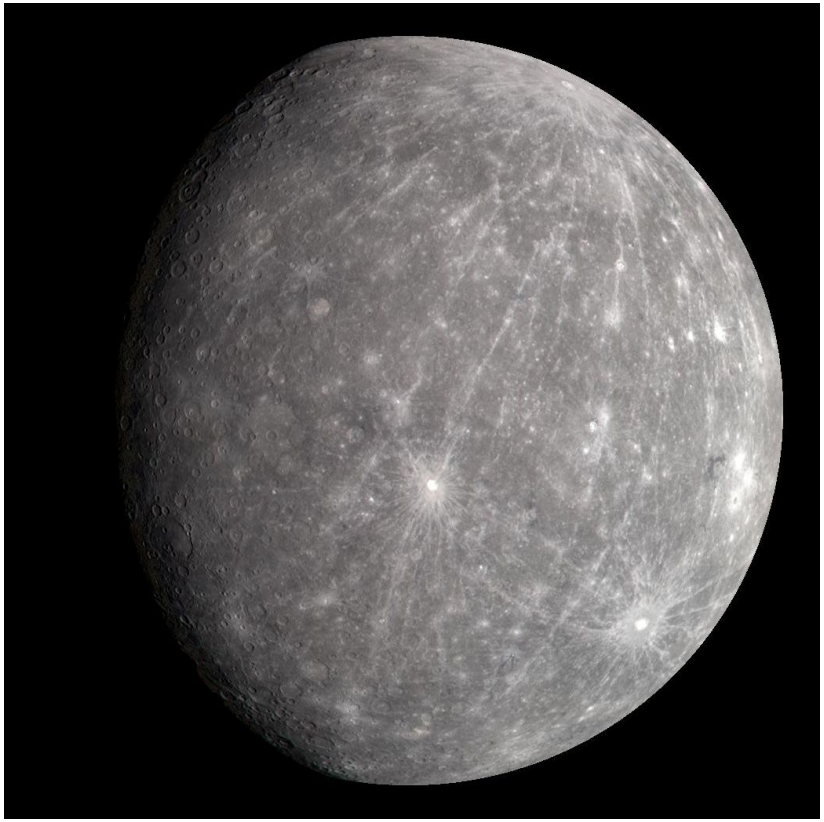
- Why is Mercury not the best planet for astrobiology?
- What happened to Venus?



The four terrestrial planets of the Solar System:



Mercury:



<u>The smallest planet:</u>

Mass: 0.05x Earth's mass

Radius 0.38x Earth's radius

Light: 6x Earth's irradiation

Mercury:



a The Moon



b Mercury

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Mercury's mass is too small to hold on to any type of atmosphere.

It's like a bigger version of the Moon. Close to the Sun!

Dayside temp: **425° C (797° F)**

Nightside temp: -150° C (-238° F)

Rot = 58.6 days

Orbit = 87.9 days

3:2 Spin Orbit resonance!



Why is Mercury hostile for life:

No atmosphere

Life forms on the surface of Mercury are exposed to the vacuum of space.

No liquids

Mercury has no liquids on its surface which makes it difficult for life to evolve.

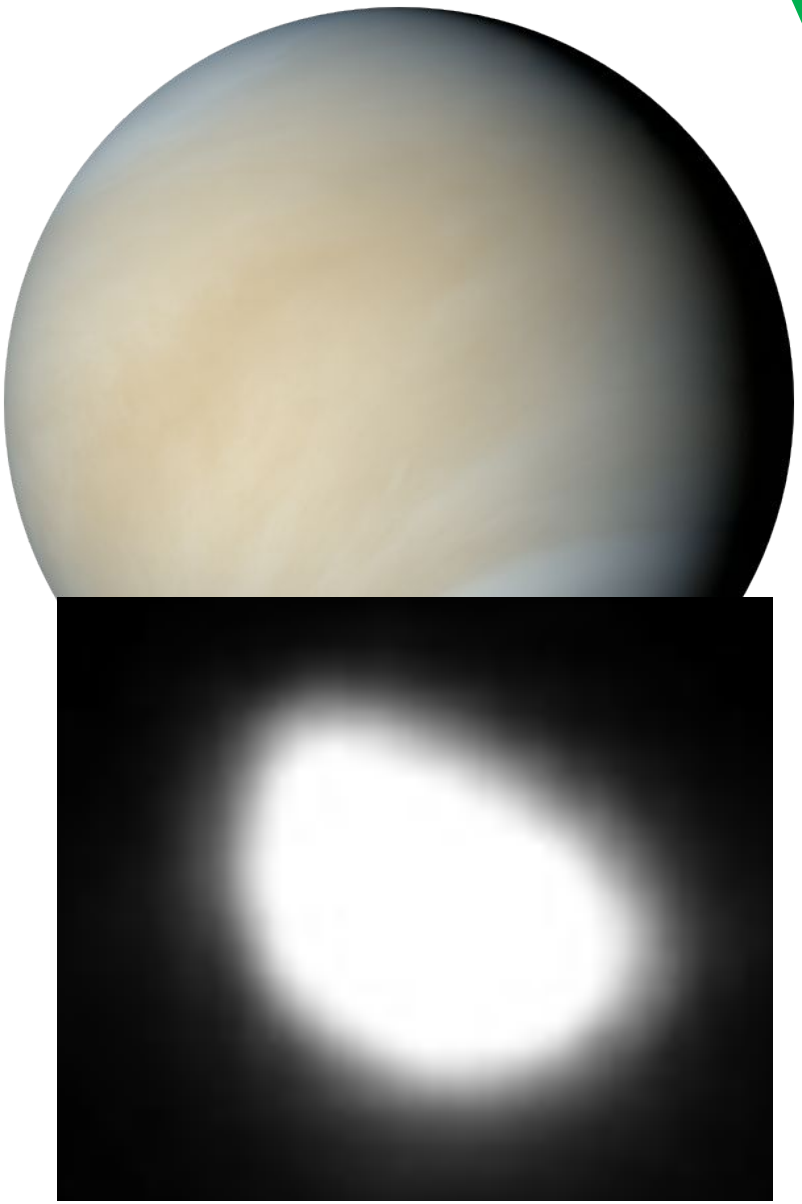
Extreme temperatures

A life form on the surface would need to survive 600° C difference in Temperature

No magnetic field

A weak magnetic field leads to strong irradiation on the surface which can harm life forms

Venus:



Earth's sister planet:

Mass: 0.815x Earth's mass

Radius 0.952x Earth's radius

Light: 2x Earth's irradiation

Venus has a thick atmosphere with 100% cloud coverage. This raises the question:

What is underneath the clouds?
What is the surface of Venus like?
Could there be life?

Could there be life on Venus?



We need to get to the surface of Venus

Telescope on Earth



Well… not much to detail we can see

Space telescope



Clouds and atmospheric structure

Magellan spacecraft



Radar map of the surface below the clouds

Missions to Venus: Venera

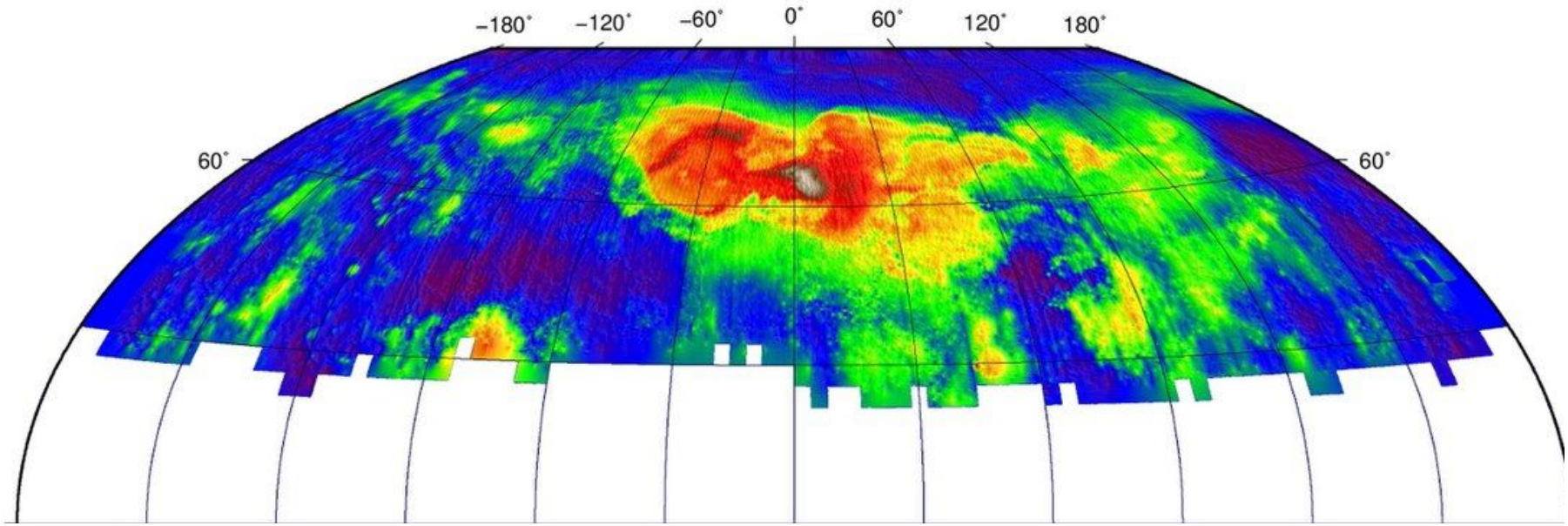
- The Venera program was active between 1961 and 1984:
  - 18 probes were launched
  - 13 probes entered Venus
  - 10 reached the surface
- Time on the surface: 23 minutes (initial probes) up to about two hours (final probes)
- First man-made devices to enter the atmosphere of another planet (Venera 4 on October 18, 1967)
- First to make a soft landing on another planet (Venera 7: December 15, 1970)
- First to return images from the planetary surface (Venera 9: June 8, 1975)





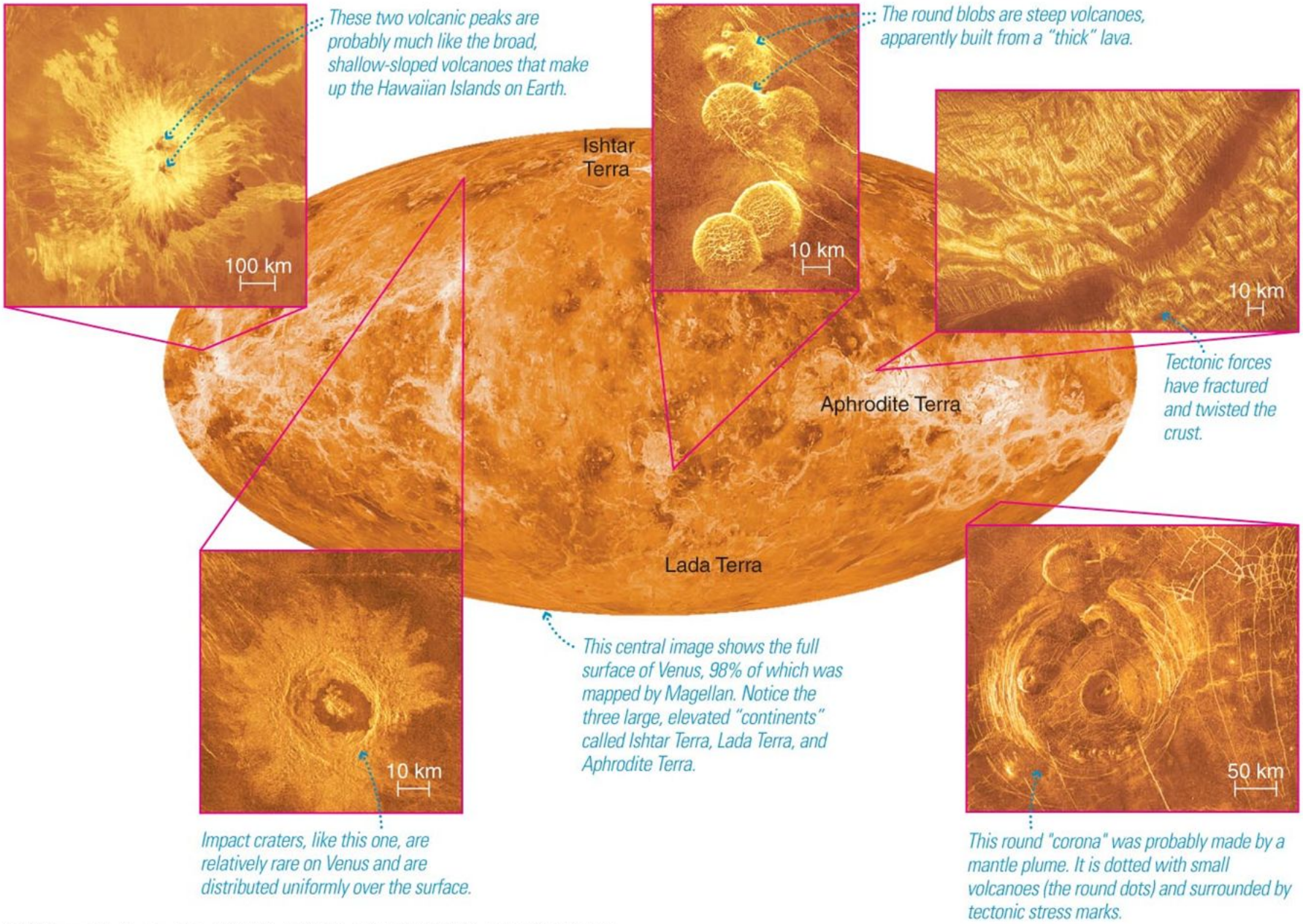
Missions to Venus: Venera

- First to perform high-resolution radar mapping of Venus (Venera 15: June 2, 1983)
  - Red parts are mountains, blue part ar basins



- Venera 13 sent the first recorded sound from another planet. (1 March 1982)

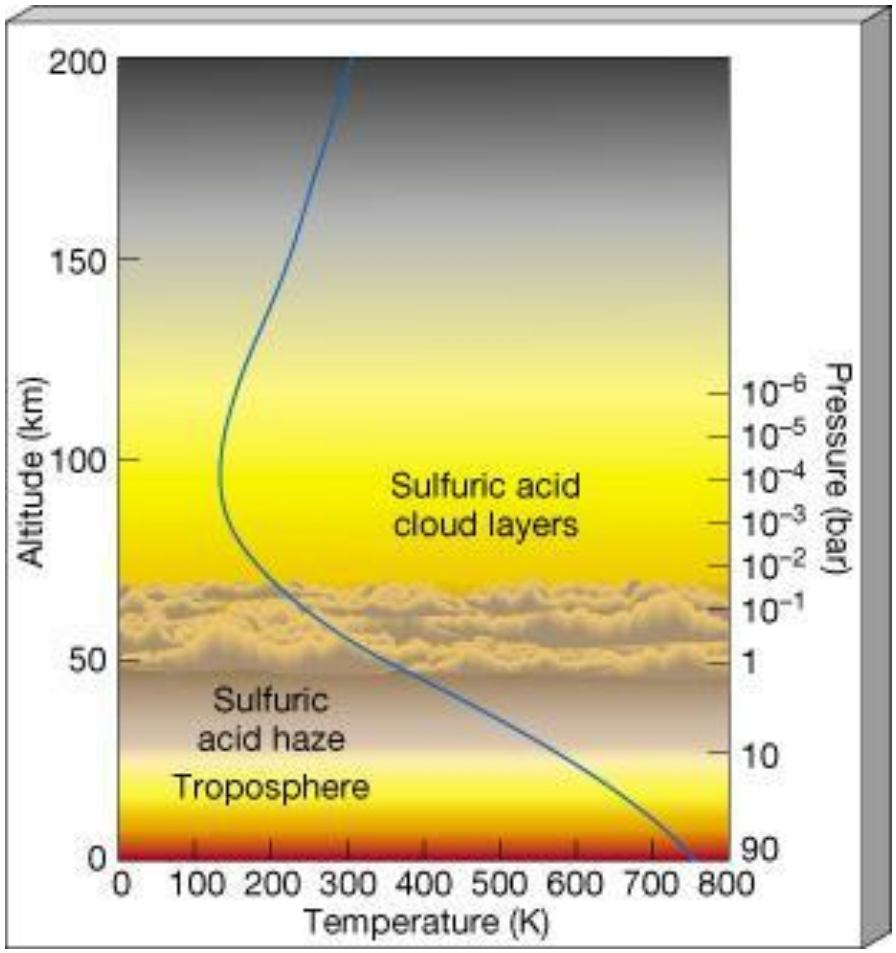




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Atmosphere of Venus:

General: Hot, dense, carbon dioxide (CO2)



- **90x more massive than Earth's atmosphere**
- Much greater in height (50km)
- Temperature drops more rapidly with altitude
- Surface winds: 4mph
- **Carbon dioxide (CO2) 97%, Nitrogen (N2) 3%**
- Traces of water vapor, carbon monoxide, sulfur dioxide, and argon. No oxygen.
- Clouds are mainly made from sulfuric acid

What happened?

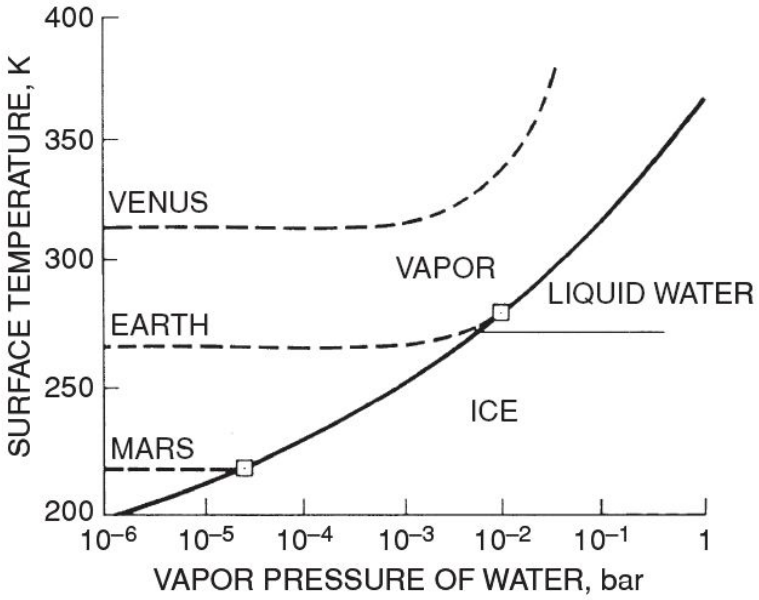
What happened on Earth:

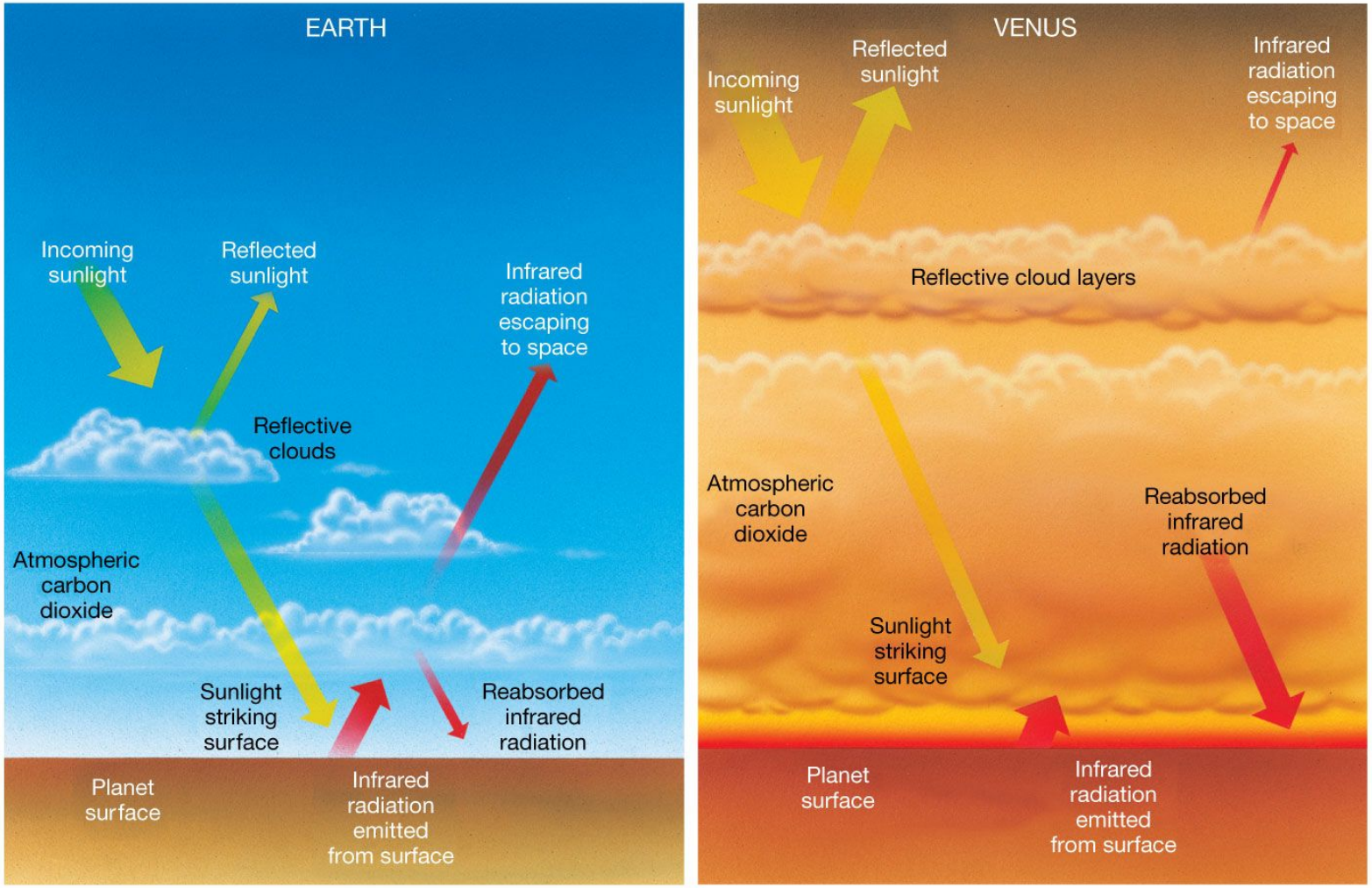
- The Earth is further away from the Sun, leading to colder temperatures
- At colder temperatures, water condenses and remains liquid on the surface
- Liquid water removes CO2 from the atmosphere (Carbonate–silicate cycle)
- Less water and less CO2 cools down the atmosphere, stabilizing it

What happened on Venus:

- Venus is closer to the sun, thus hotter
- Hotter means more water can evaporate
- CO2 also remains in the atmosphere
- Water and CO2 trap escaping heat
- Venus becomes increasingly hotter

➡ **A runaway greenhouse effect occurs**





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Atmosphere is much deeper and denser, therefore a much smaller fraction of the IR radiation escapes into space. Result is a much stronger greenhouse effect.

→ **Runaway greenhouse effect.**

What happened?

dry: 100 ppm

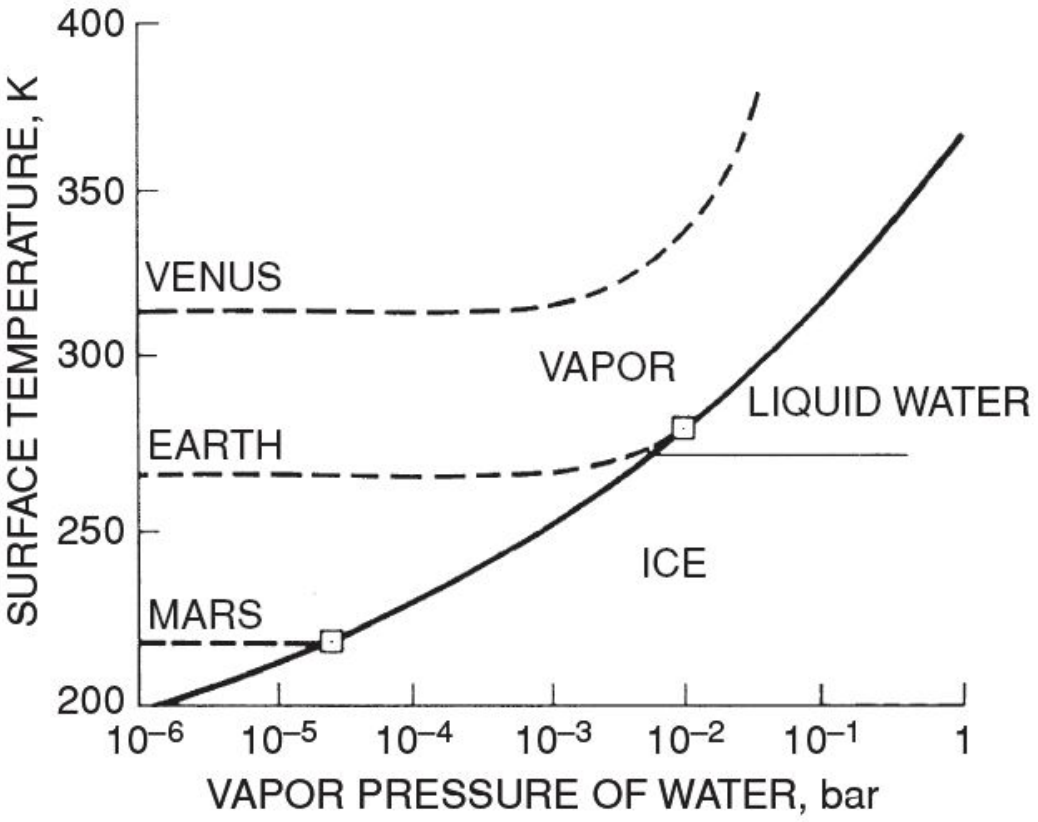
10^{-5} Earth's oceans

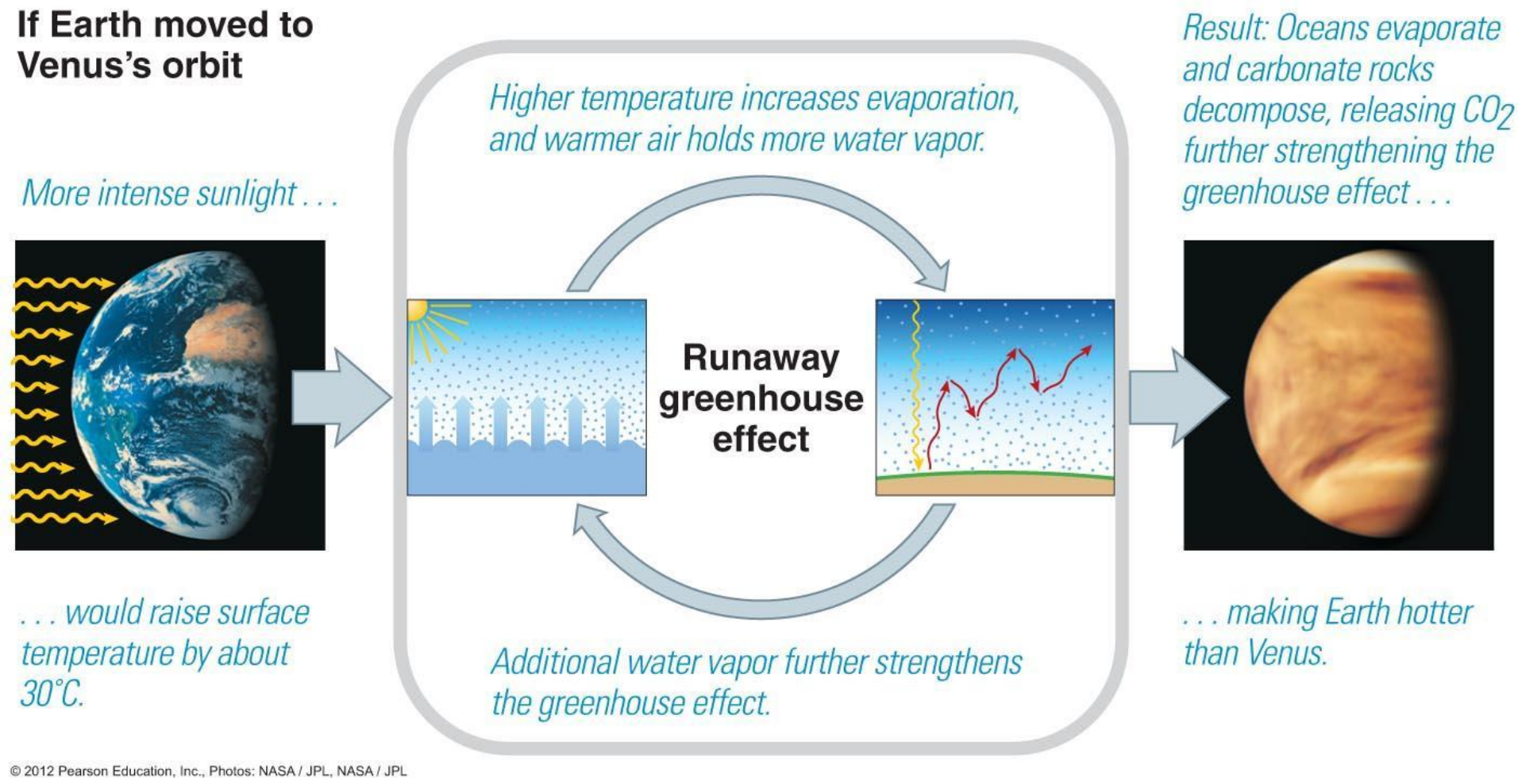
but D/H high!

H_2O remained in atmosphere higher *T* (greenhouse effect)

⇒ photodiss.

⇒ H escapes





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It is all about the water! Venus maybe never had the oceans to absorb CO_2 (because the temperature was higher)

What happened to Venus?

Aug 11, 2016

NASA Climate Modeling Suggests Venus May Have Been Habitable

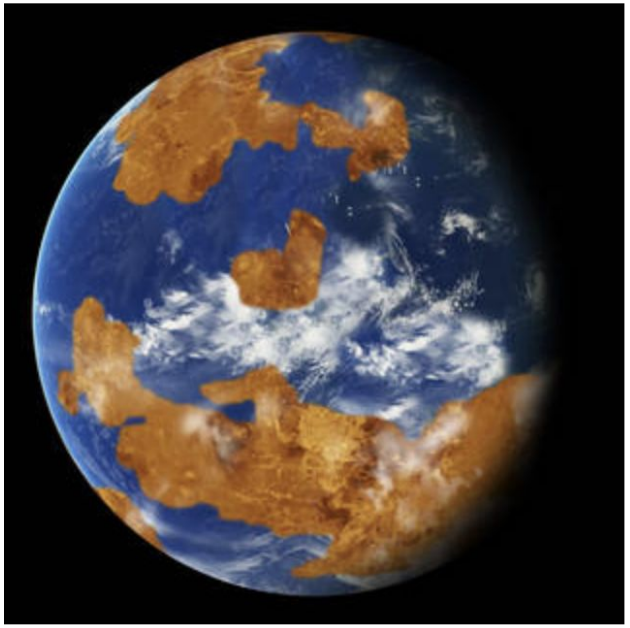
Venus may have had a shallow liquid-water ocean and habitable surface temperatures for up to 2 billion years of its early history, according to computer modeling of the planet's ancient climate by scientists at NASA's Goddard Institute for Space Studies (GISS) in New York.

The findings, published this week in the journal Geophysical Research Letters, were obtained with a model similar to the type used to predict future climate change on Earth.

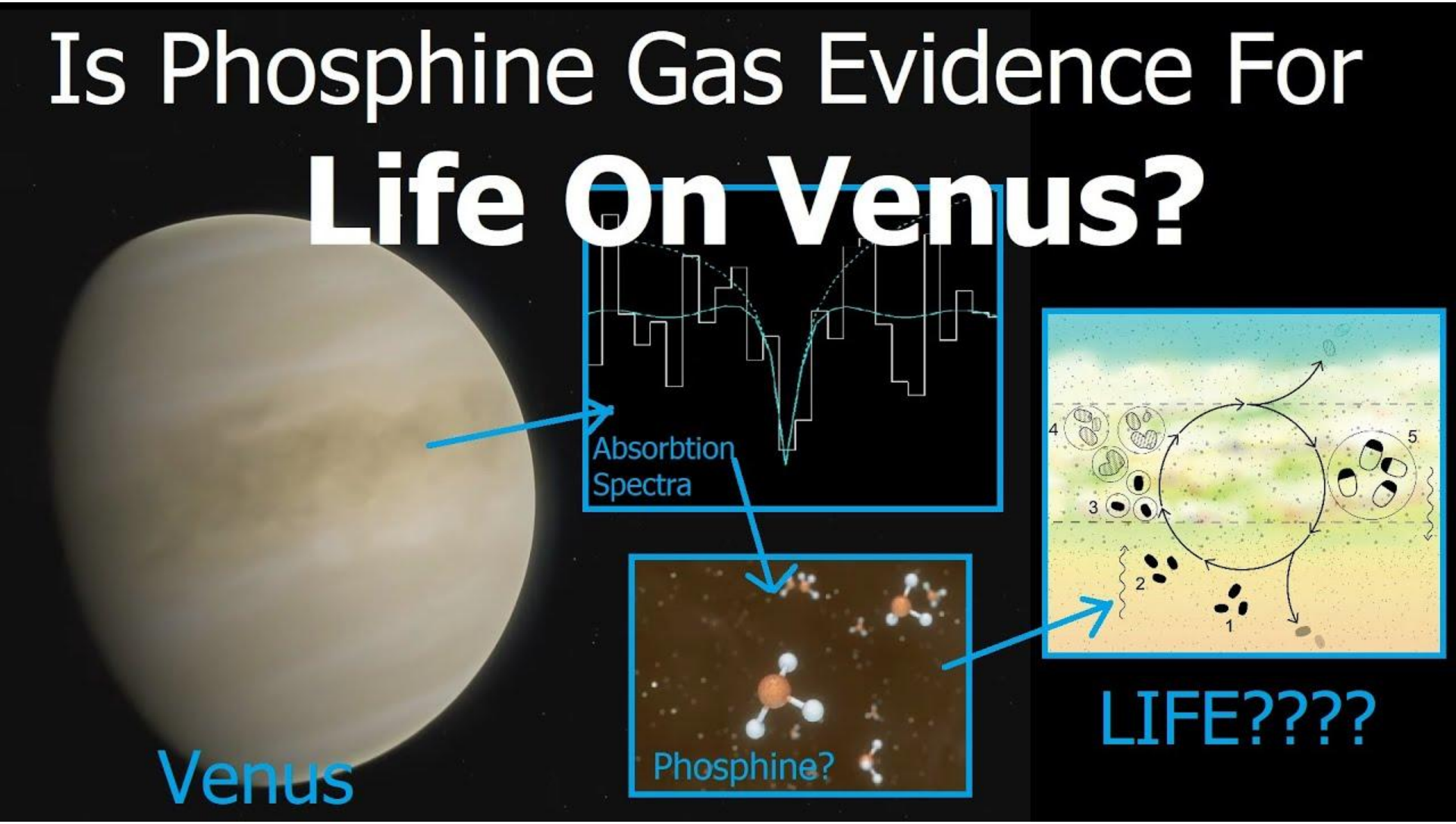
"Many of the same tools we use to model climate change on Earth can be adapted to study climates on other planets, both past and present," said Michael Way, a researcher at GISS and the paper's lead author. "These results show ancient Venus may have been a very different place than it is today."

Venus today is a hellish world. It has a crushing carbon dioxide atmosphere 90 times as thick as Earth's. There is almost no water vapor. Temperatures reach 864 degrees Fahrenheit (462 degrees Celsius) at its surface.

Scientists long have theorized that Venus formed out of ingredients similar to Earth's, but followed a different evolutionary path. Measurements by NASA's Pioneer mission to Venus in the 1980s first suggested Venus originally may have had an ocean. However, Venus is closer to the sun than Earth and receives far more sunlight. As a result, the planet's early ocean evaporated, water-vapor molecules were broken apart by ultraviolet radiation, and hydrogen escaped to space. With no water left on the surface, carbon



Observations suggest Venus may have had water oceans in its distant past. A land-ocean pattern like that above was used in a climate model to show how storm clouds could have shielded ancient Venus from strong sunlight and made the planet habitable.
Credits: NASA



…..or just unexpected cloud chemistry?

Phosphine on Venus: A heated debate

What happened?

- In 2020, astronomers published a potential detection of Phosphine on Venus
- On Earth, phosphine in the atmosphere is produced by life!
- Therefore, this was discussed as possible signs of life on Venus

What is the problem with this 'detection'?

Abiotic Phosphine	**Only 1 Measurement**	**Not reproducible**
There might be an abiotic way to produce phosphine on Venus	Only 1 dataset has evidence of phosphine. Is the signal real?	Other scientists have studied the same data and found no signal

Why is this debate so important for astrobiology?

- It highlights all difficulties in claiming a biosignature detection
- Rigorous frameworks are needed that outline steps if such a discovery is made
- Claims need to be modest and responses need to be respectful