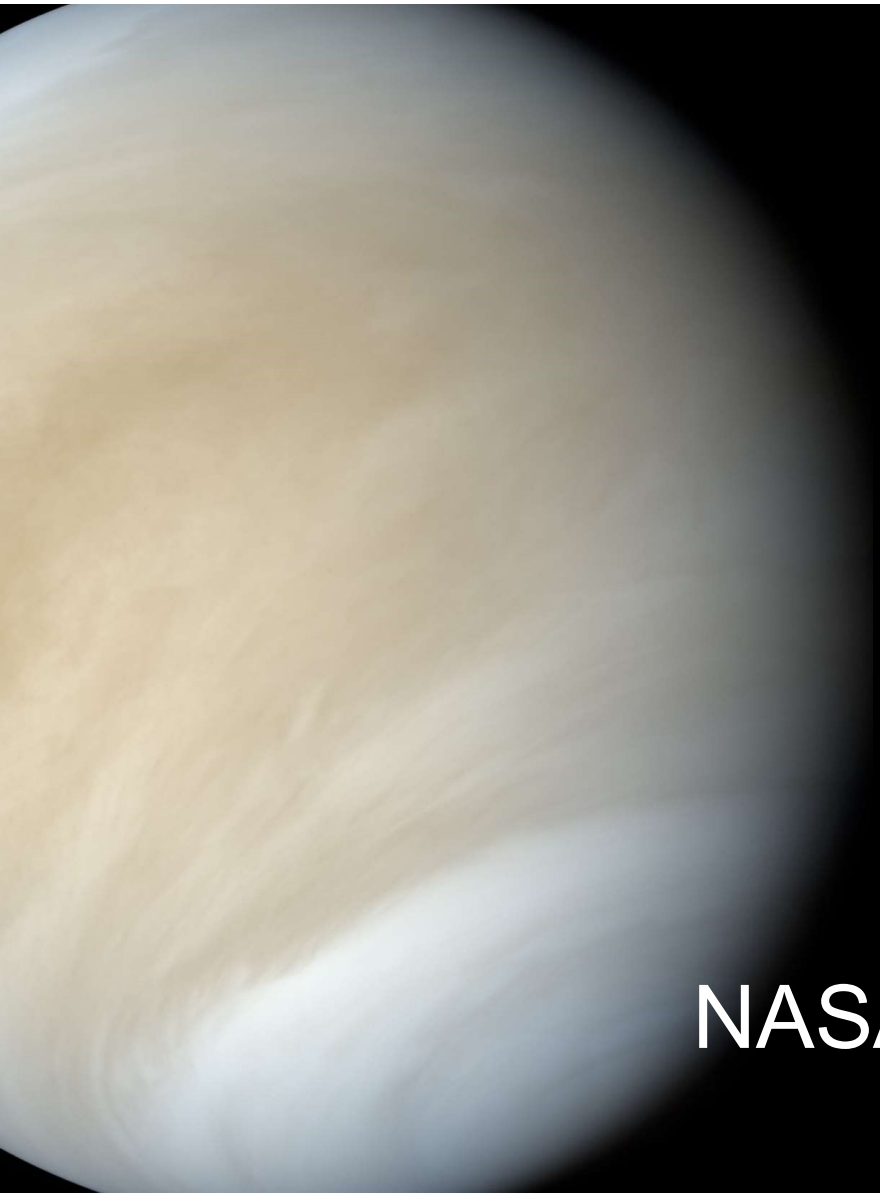
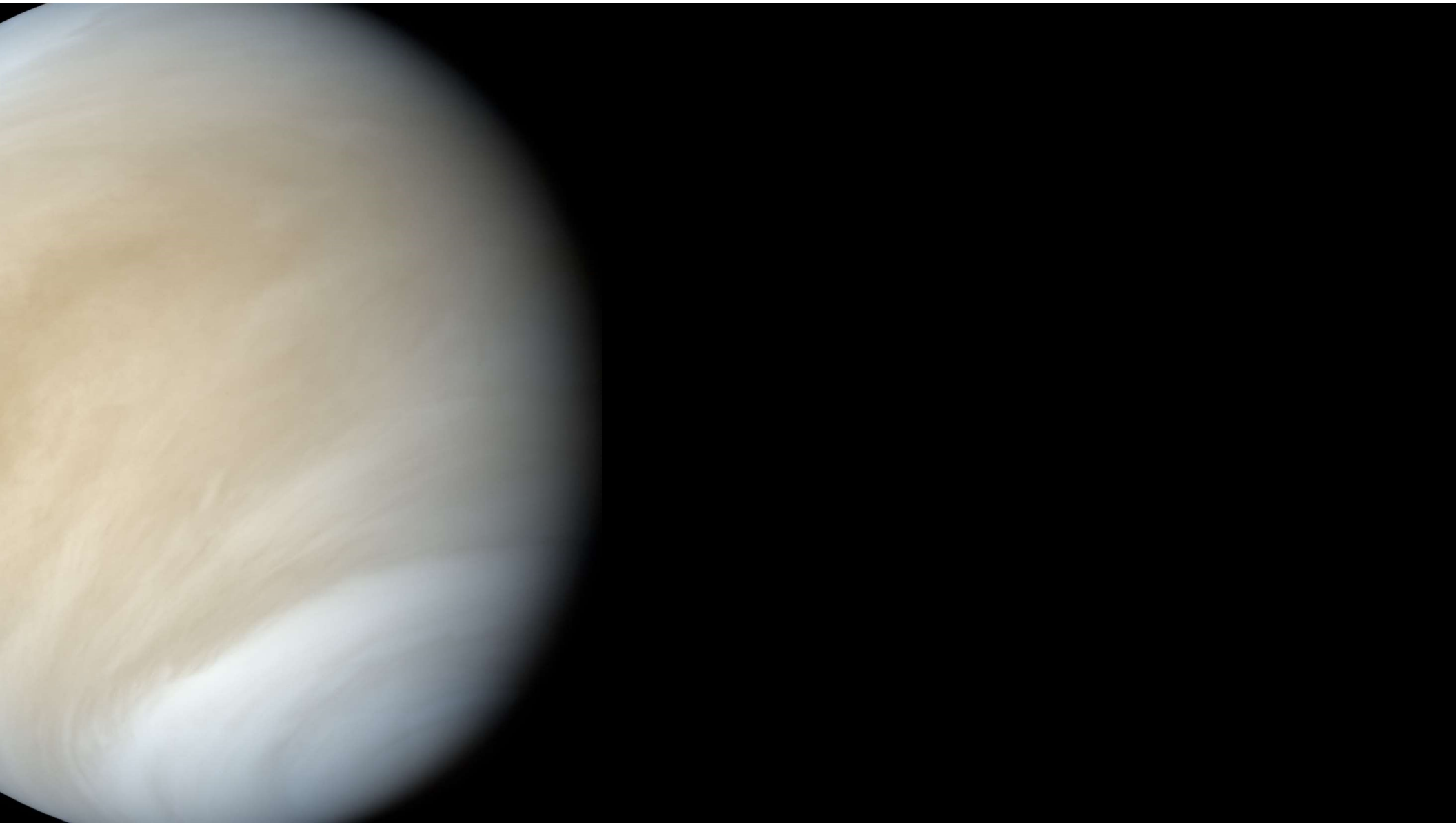
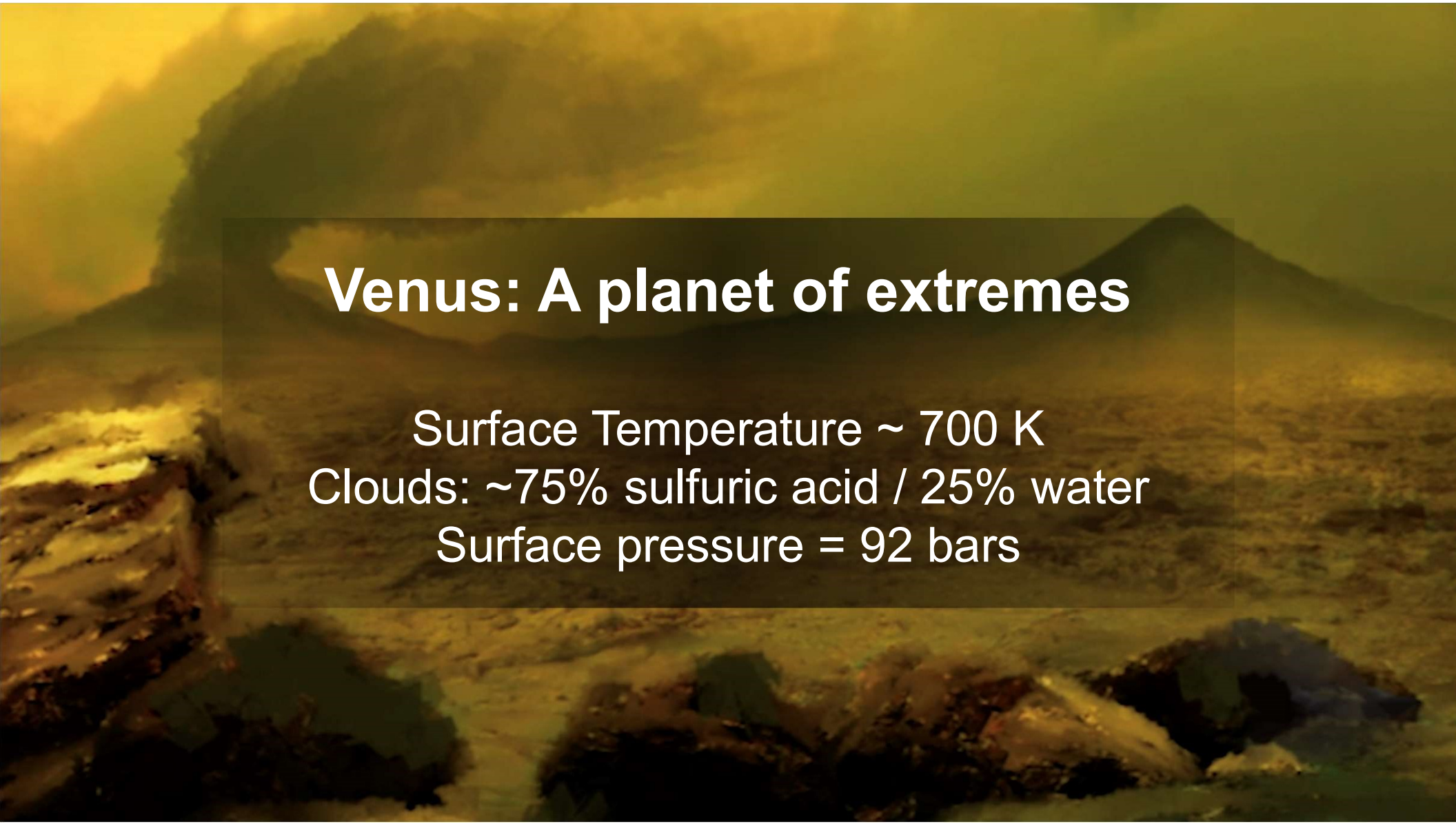


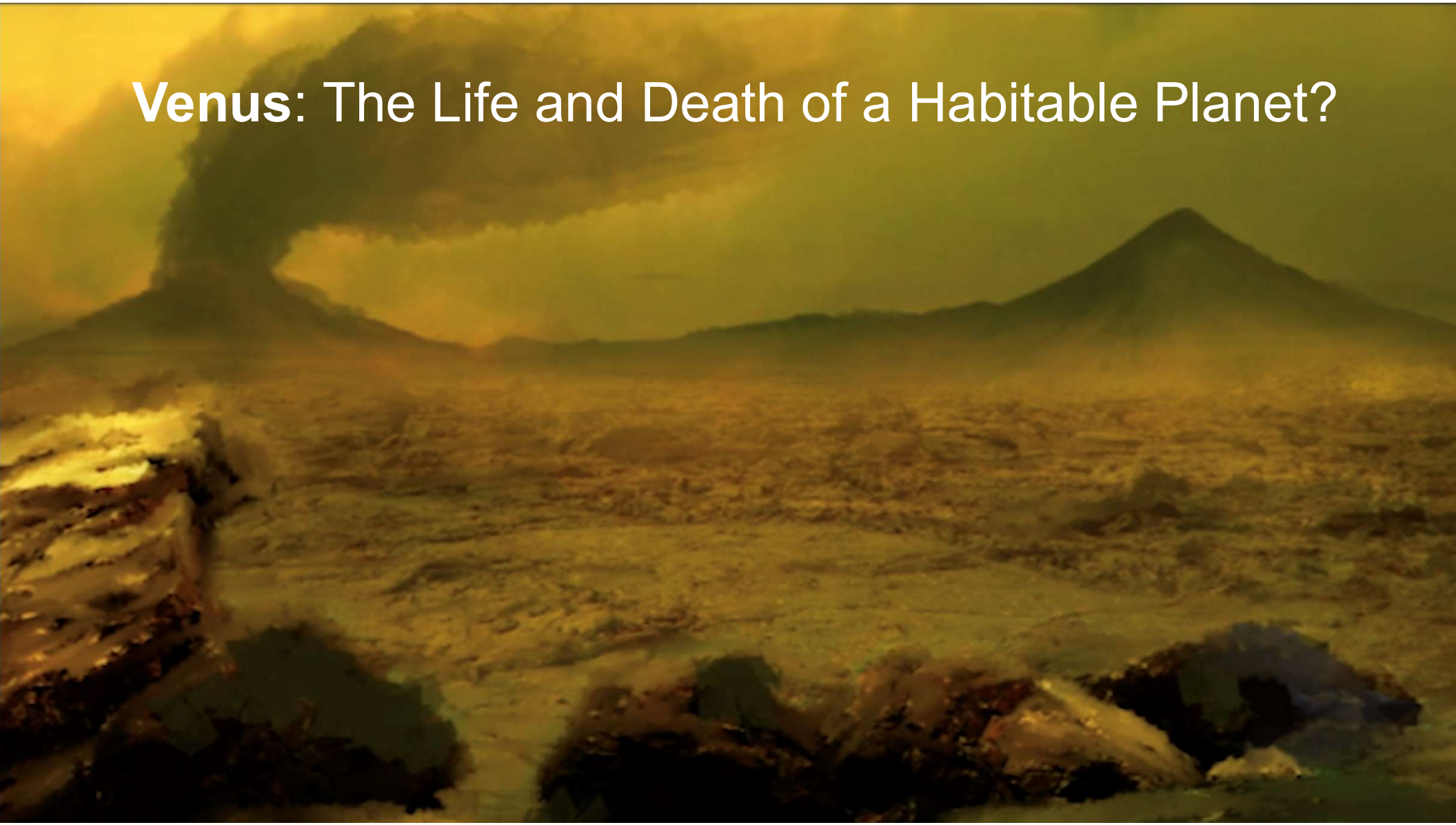
Venus:
the exoplanet in our backyard

Giada Arney
NASA Goddard Space Flight Center

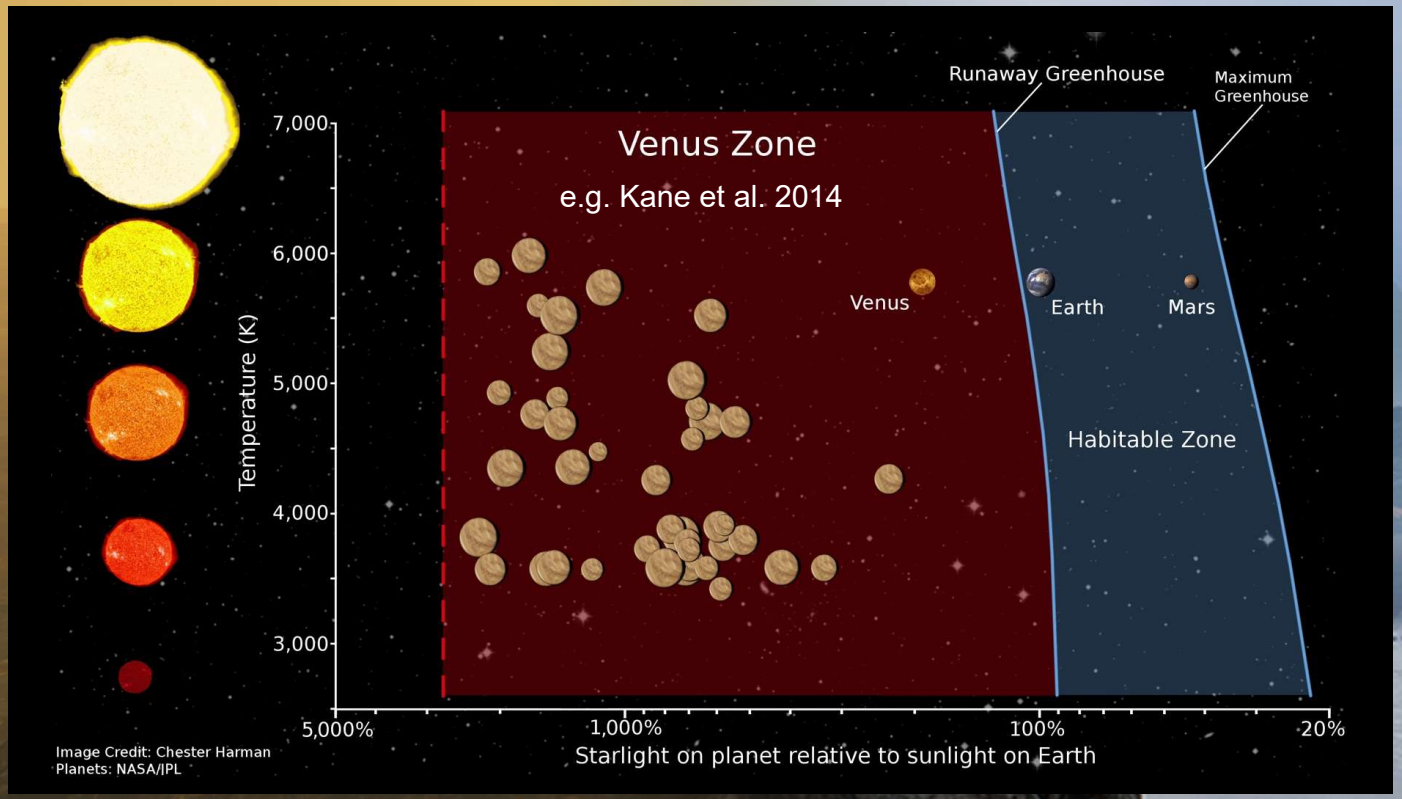



Venus: A planet of extremes
Surface Temperature ~ 700 K
Clouds: ~75% sulfuric acid / 25% water
Surface pressure = 92 bars


Venus: billions of years ago?


Venus: The Life and Death of a Habitable Planet?

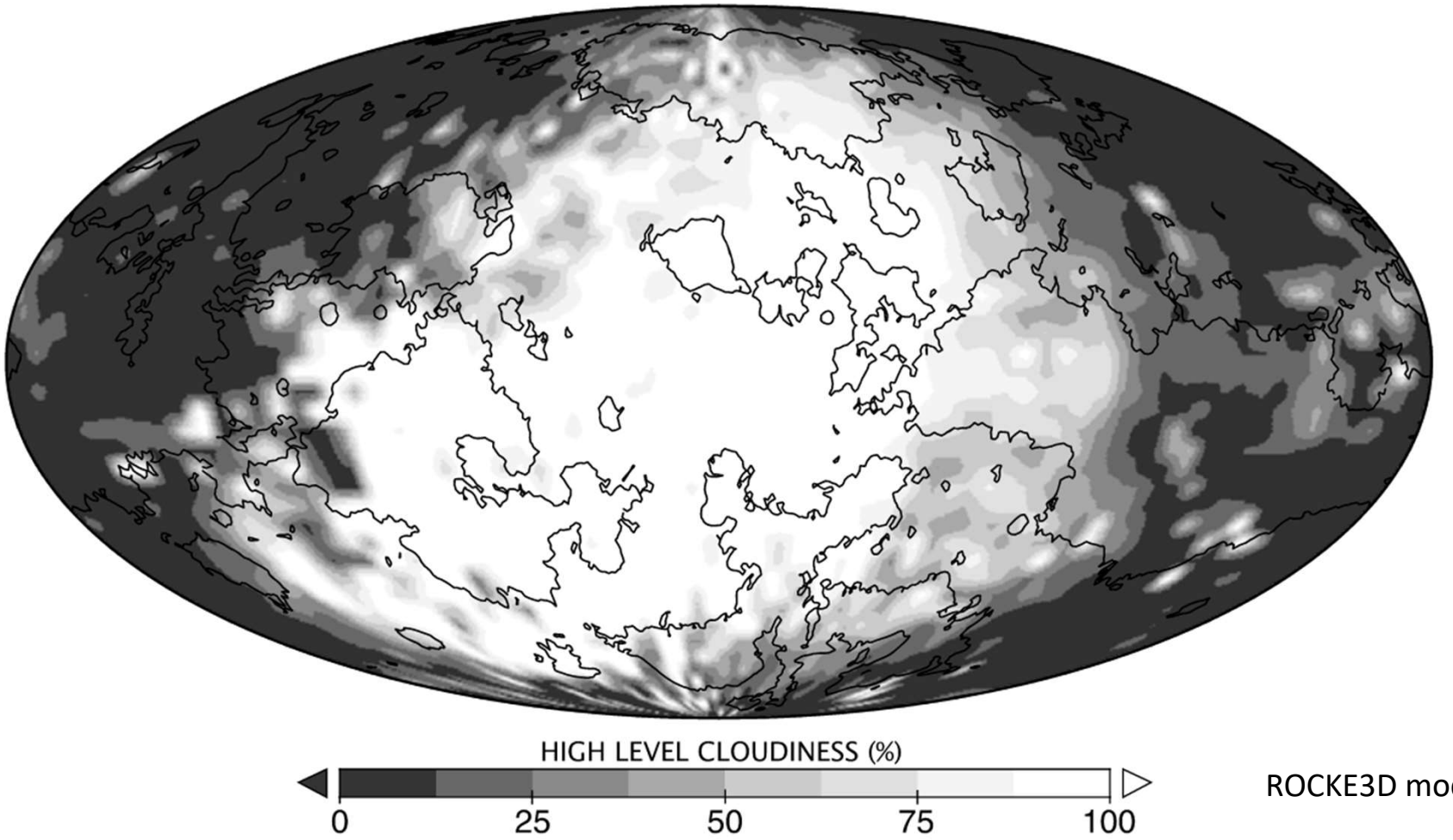
Venus helps us define the boundaries of habitability



What are the processes that can frustrate or maintain habitability?

Way et al. 2016; Way and DelGenio 2020

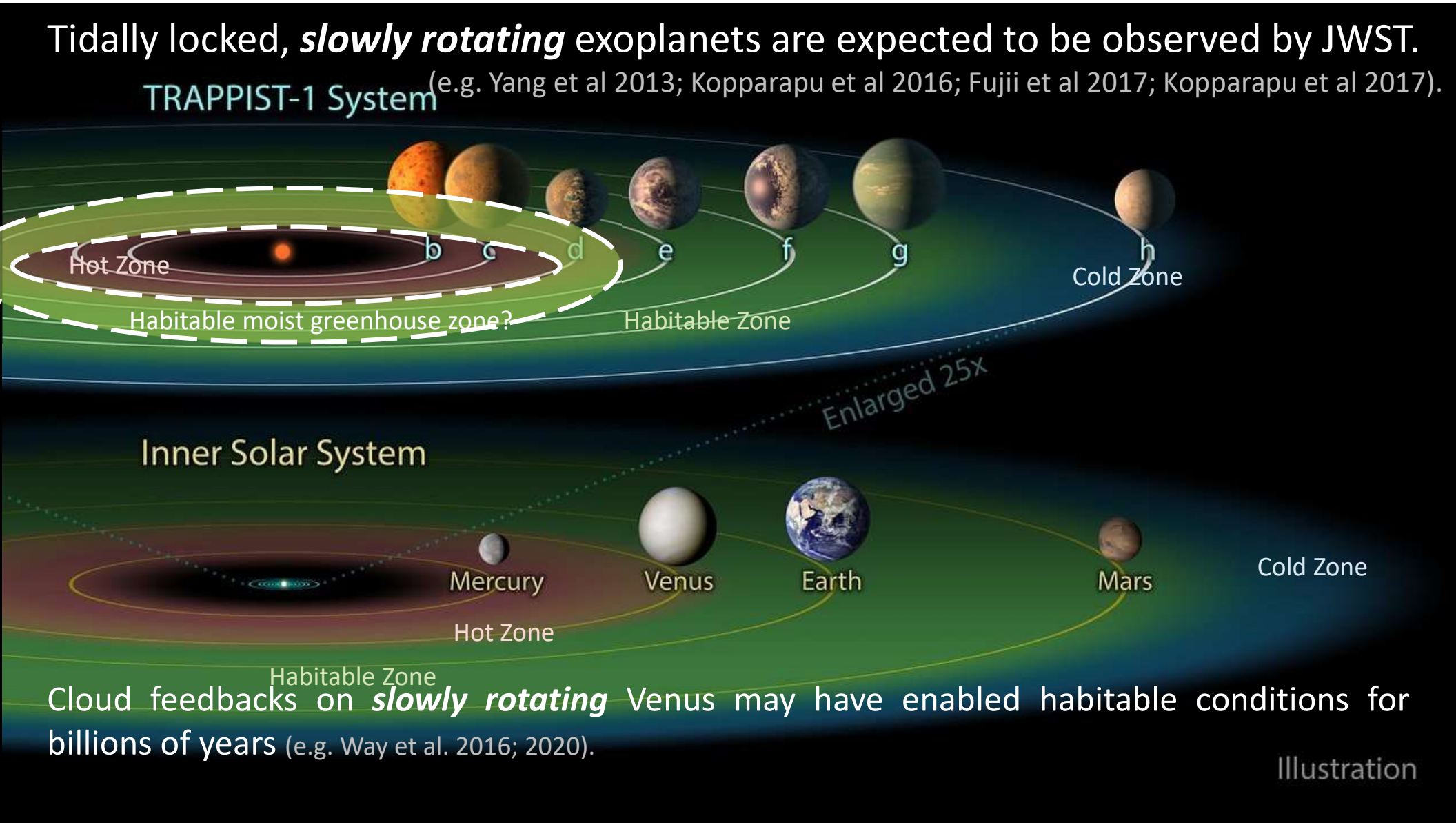
Dayside cloud-albedo feedbacks can produce **cooling** for slowly-rotating planets



ROCKE3D model

Tidally locked, ***slowly rotating*** exoplanets are expected to be observed by JWST.

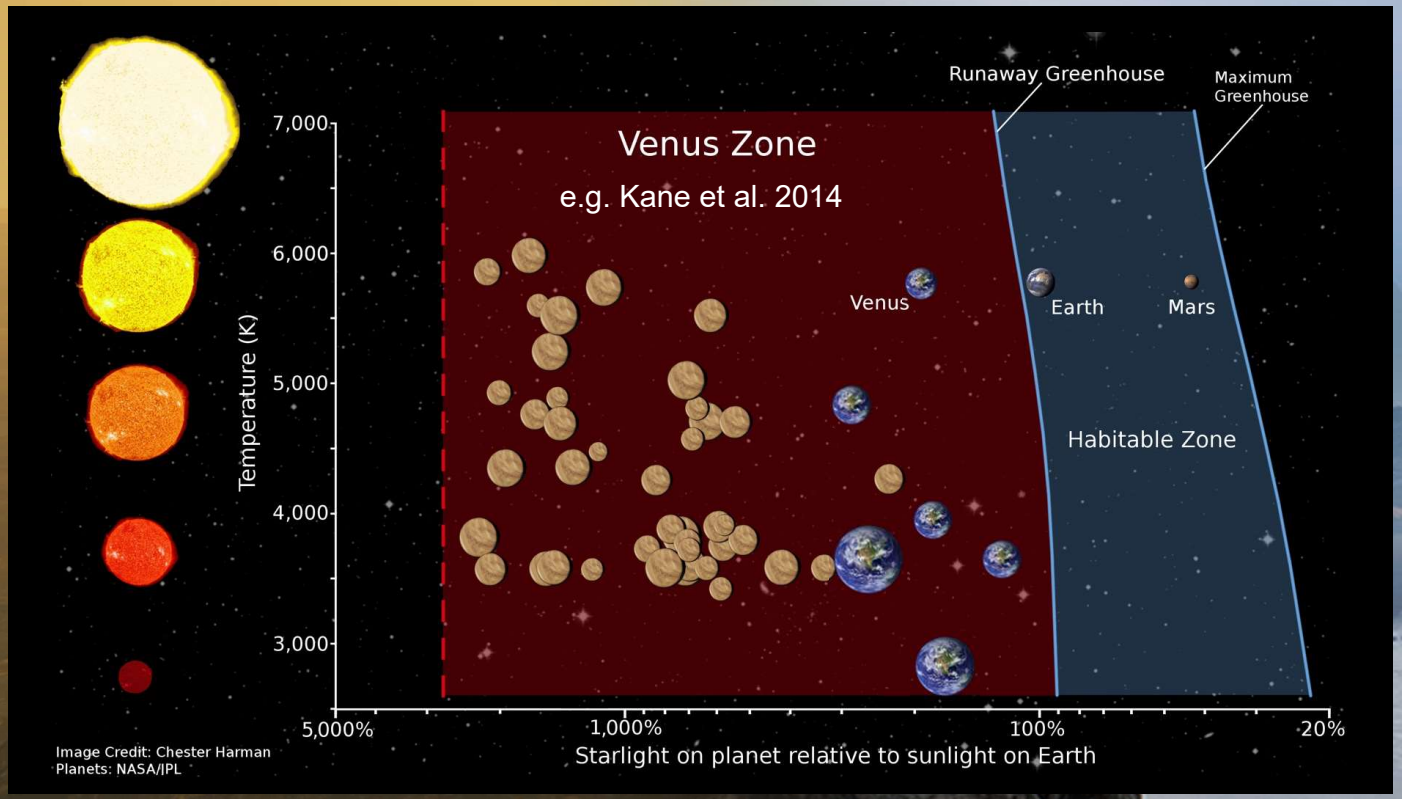
(e.g. Yang et al 2013; Kopparapu et al 2016; Fujii et al 2017; Kopparapu et al 2017).



Cloud feedbacks on ***slowly rotating*** Venus may have enabled habitable conditions for billions of years (e.g. Way et al. 2016; 2020).

Illustration

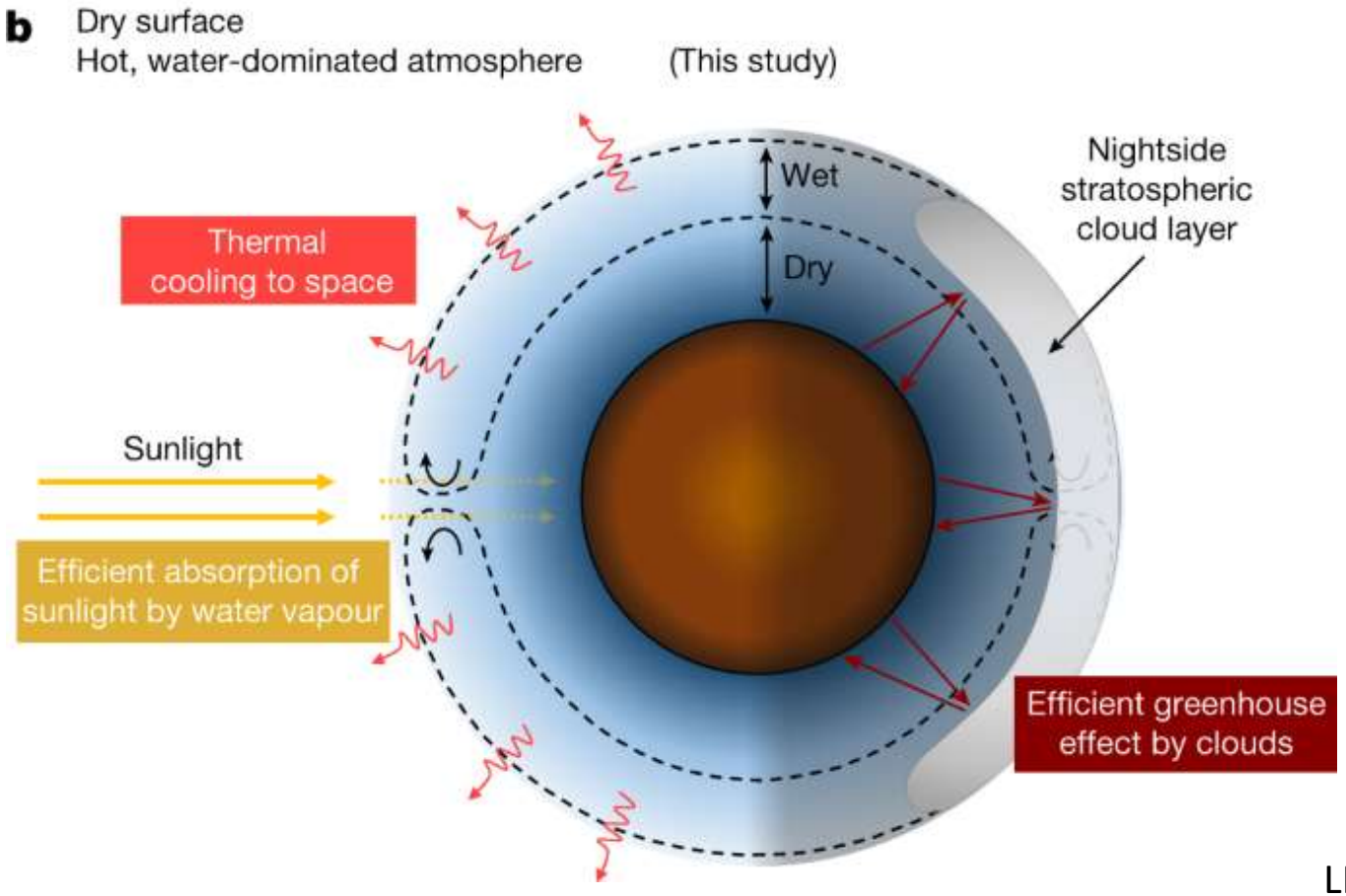
Venus helps us define the boundaries of habitability: Earths in the “Venus zone”??



What are the processes that can frustrate or maintain habitability?

Turbet et al. (2021)

Nightside stratospheric clouds can produce **warming…**the jury is still out on early Venus habitability



LMD Model

Selsis et al. (2023)

Modeling hot planet atmospheres is more complex than previously assumed.
Steam atmospheres cooler than previously thought.

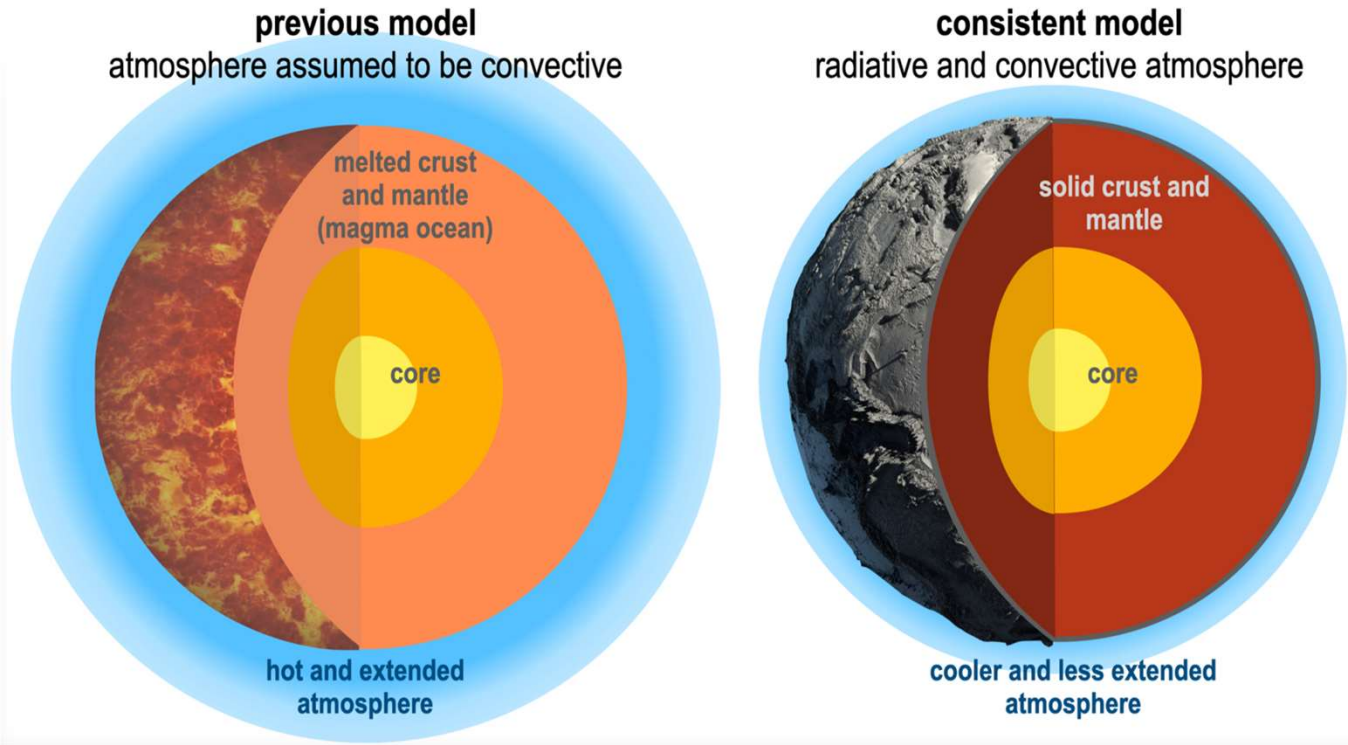


Image credit: Frank Selsis

Venus may help us search for life beyond the solar system

"Venus also has a role to play in understanding biosignature interpretation…[and] can inform our understanding and models of the likelihood of false positive biosignatures..."

-2018 NAS Astrobiology Strategy consensus report

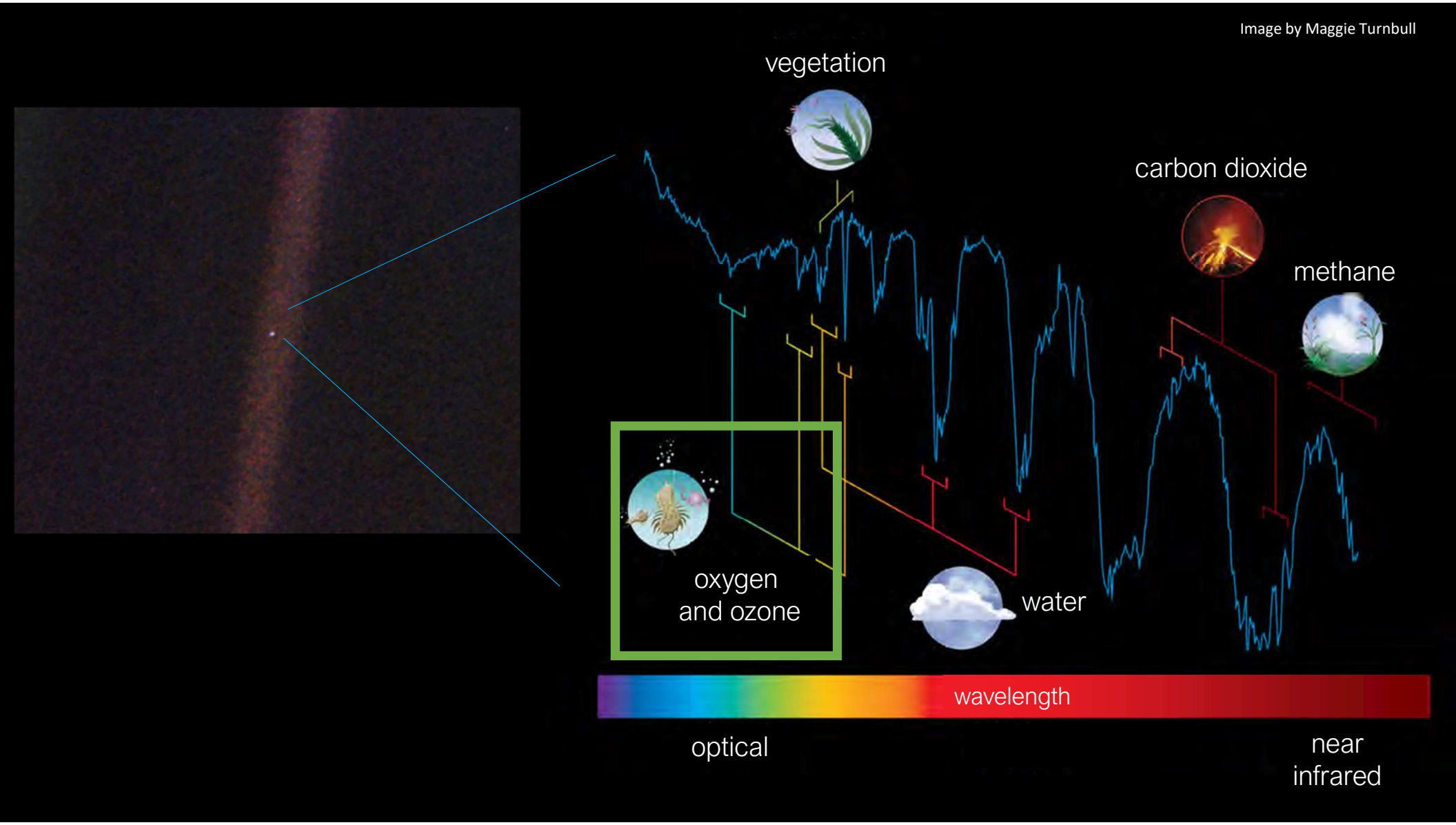
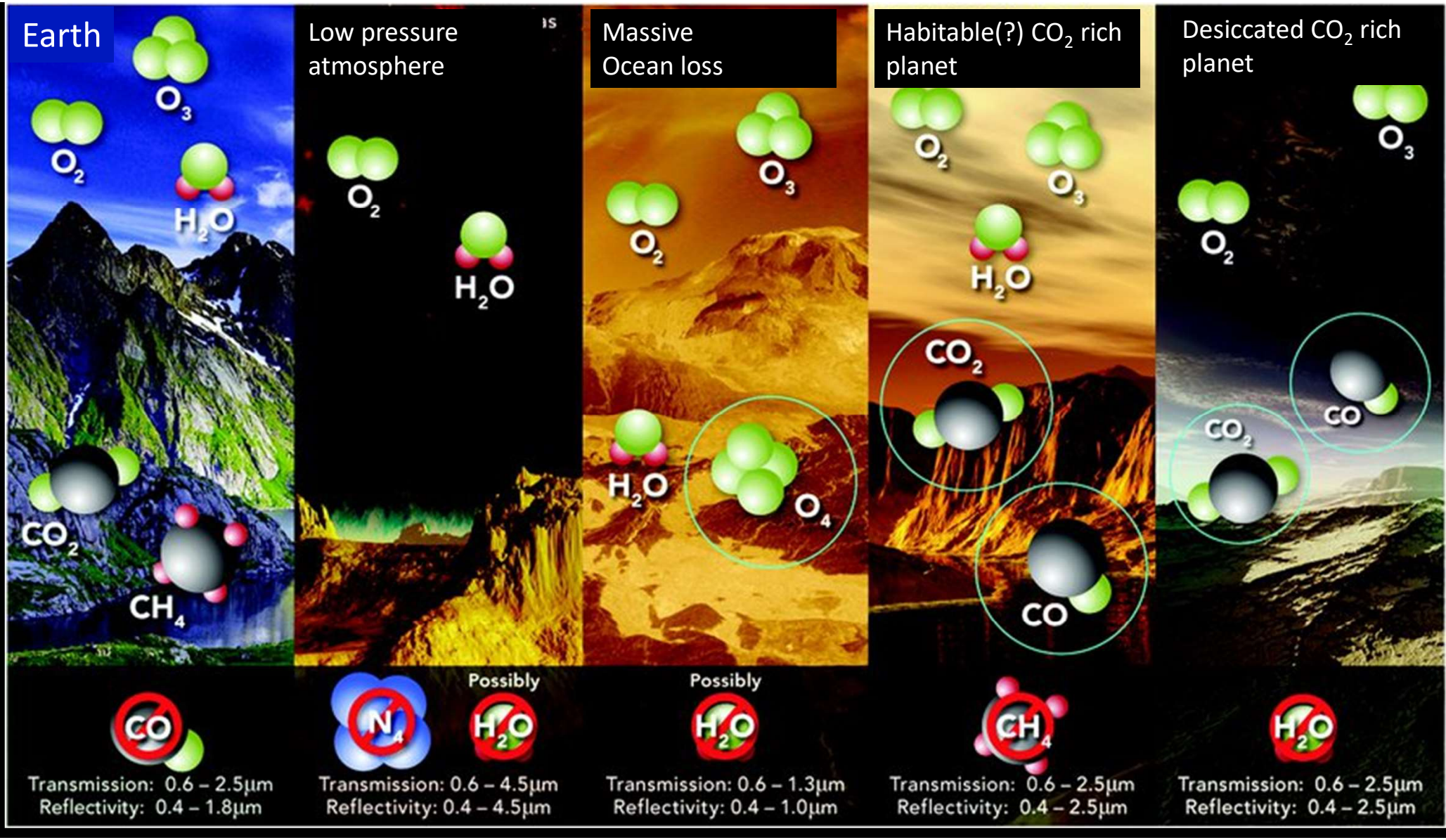
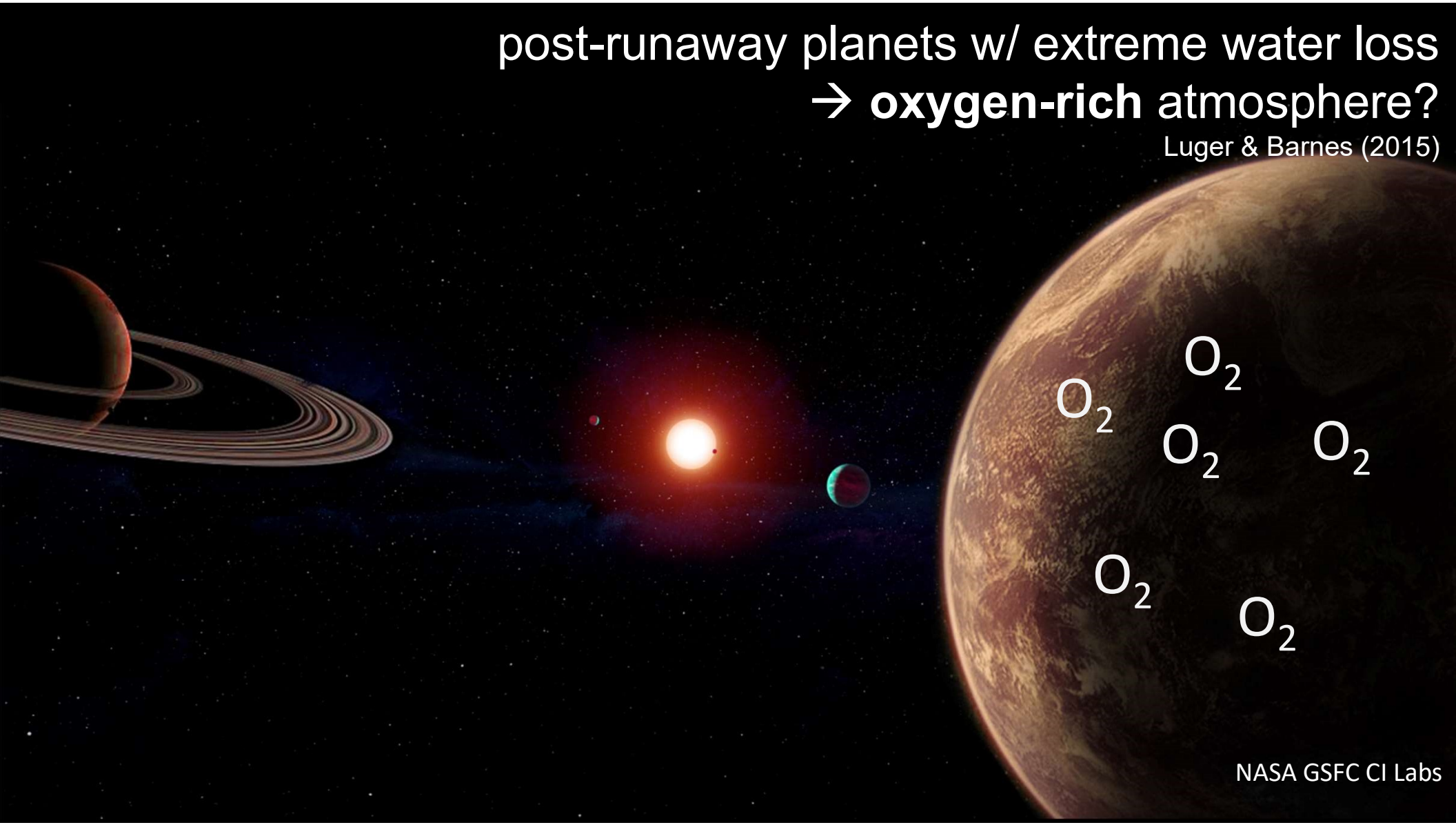
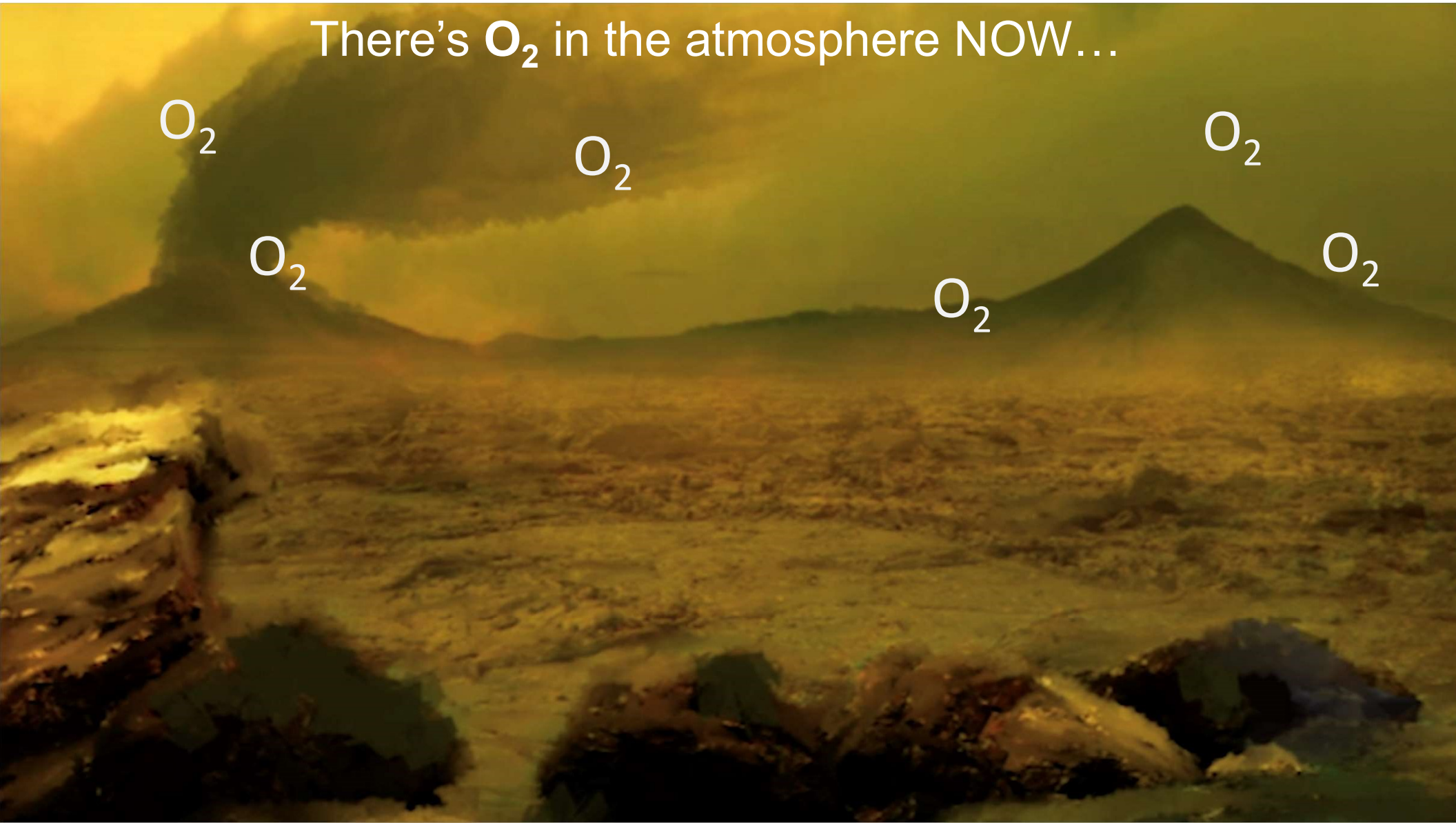


Image by Maggie Turnbull
vegetation
carbon dioxide
methane
oxygen
and ozone
water
wavelength
optical
near
infrared



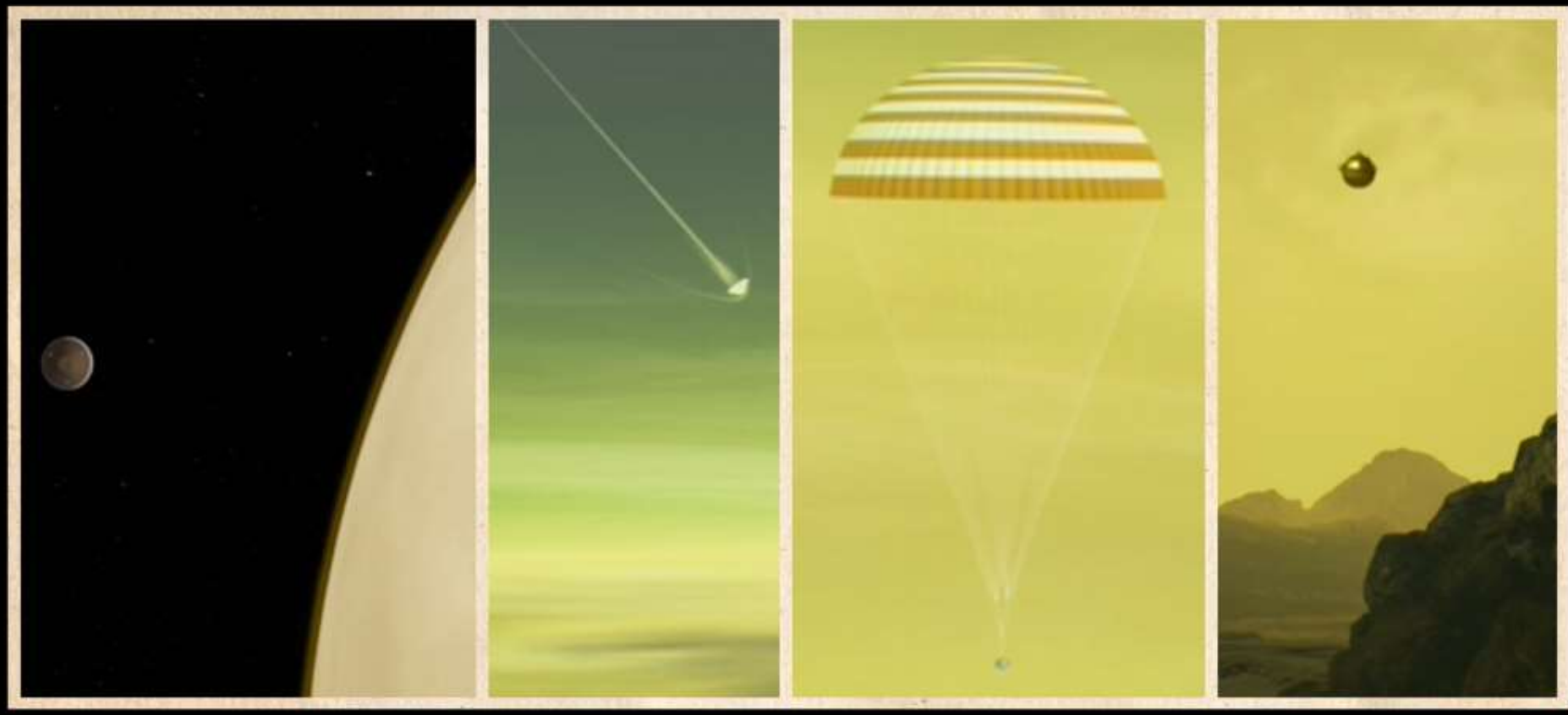
Meadows 2017

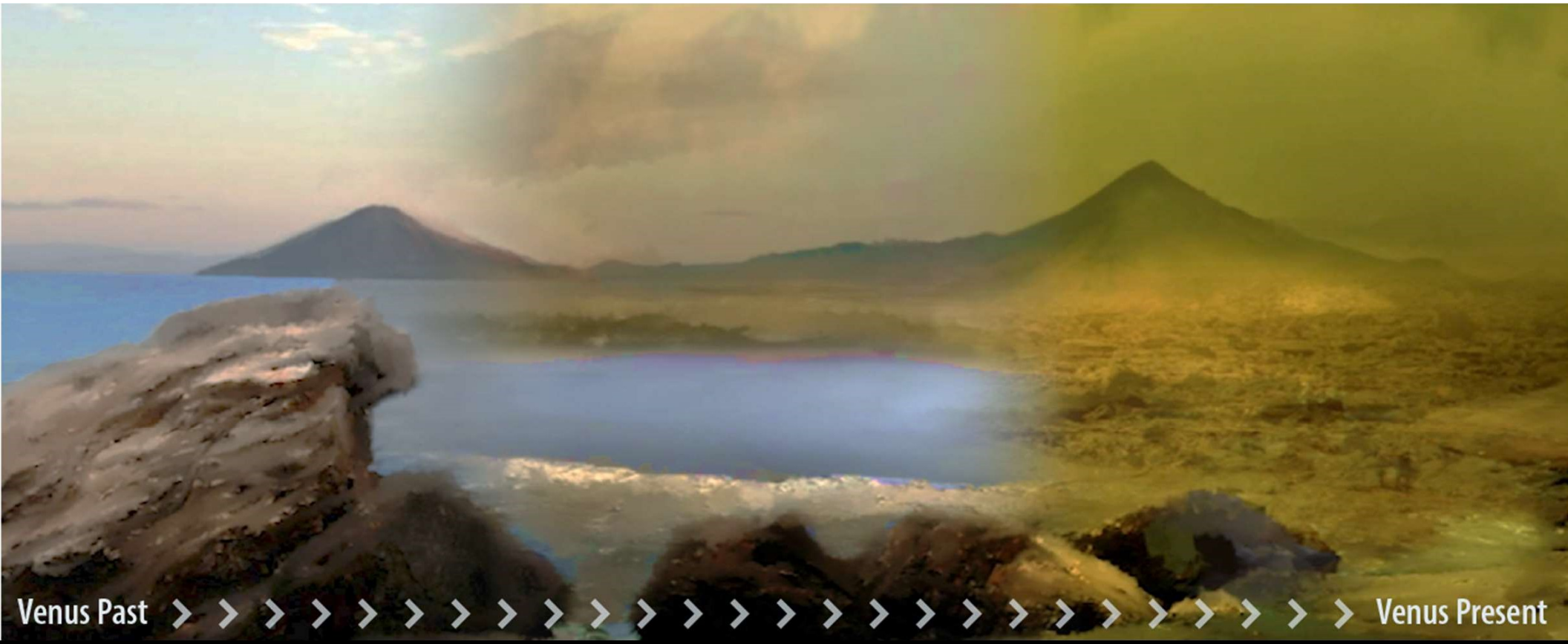

post-runaway planets w/ extreme water loss
→ **oxygen-rich** atmosphere?
Luger & Barnes (2015)
O_2
O_2
O_2
O_2
O_2
O_2
NASA GSFC CI Labs


There's O_2 in the atmosphere NOW…
O_2
O_2
O_2
O_2
O_2
O_2

DAVINCI

21st Century Probe-based Chemistry, Environments, Dynamics, and Descent Imaging of Venus atmosphere + surface



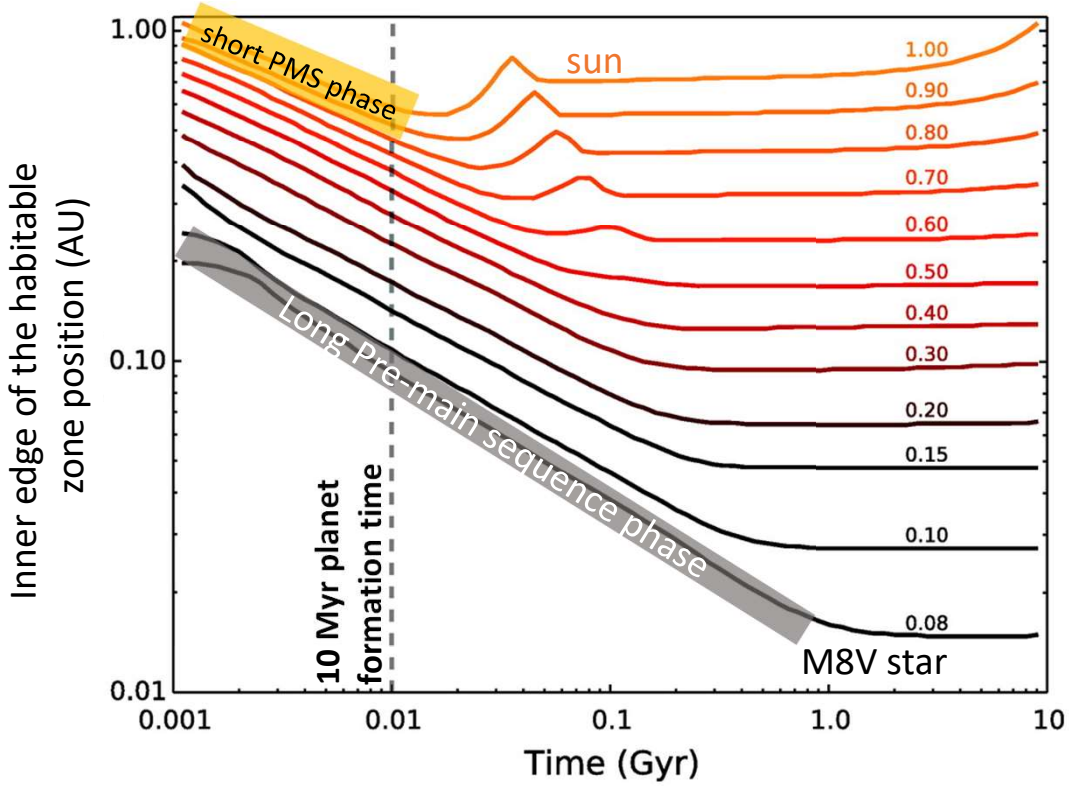


“Ultimately, the assessment of whether or not a planet is habitable will need to be embedded in the context of the outcomes of terrestrial exoplanet evolution.”

- 2018 *Exoplanet Science Strategy* report

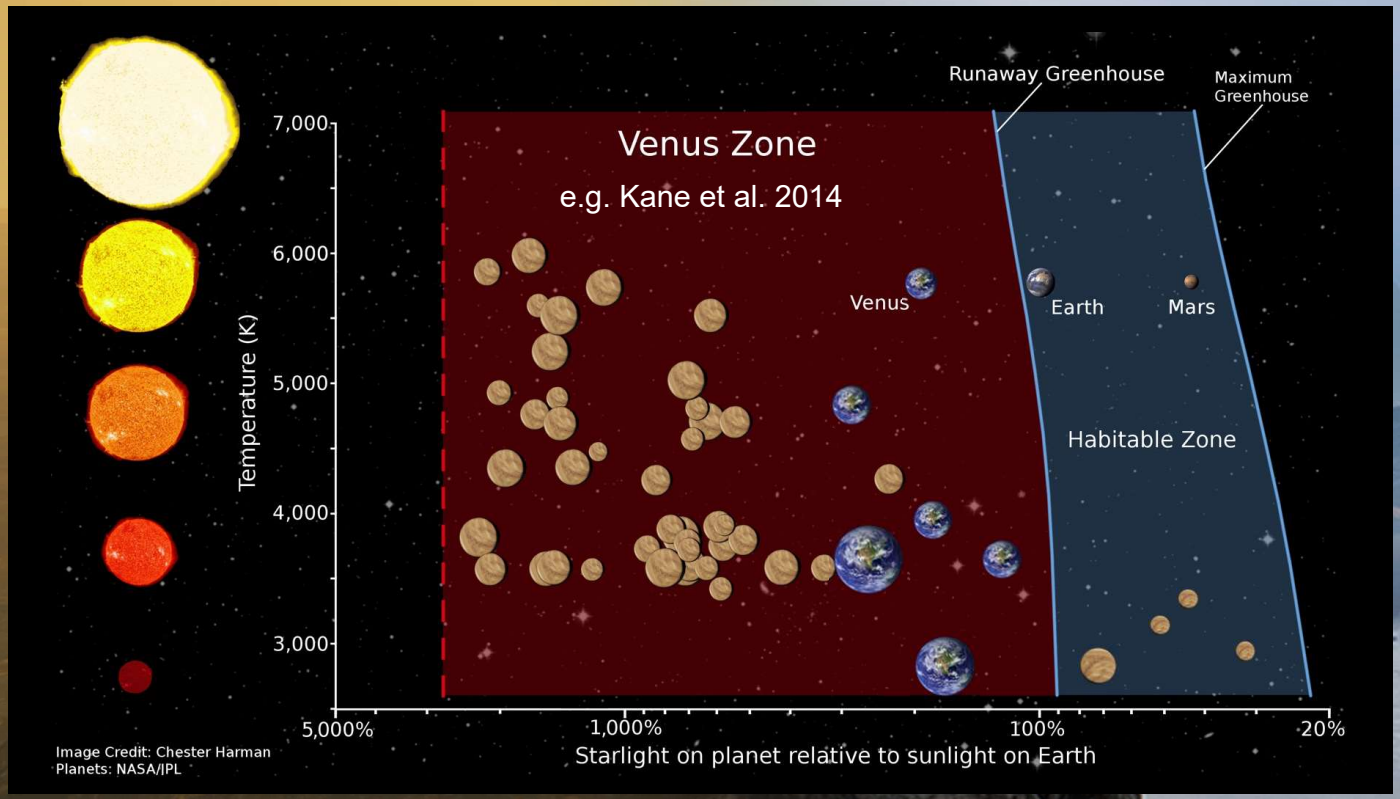
Extras

The **super-luminous pre-main sequence phase** (period of contraction as the protostar is turning into a star) lasts longer for lower mass stars → can turn habitable zone planets into Venuses

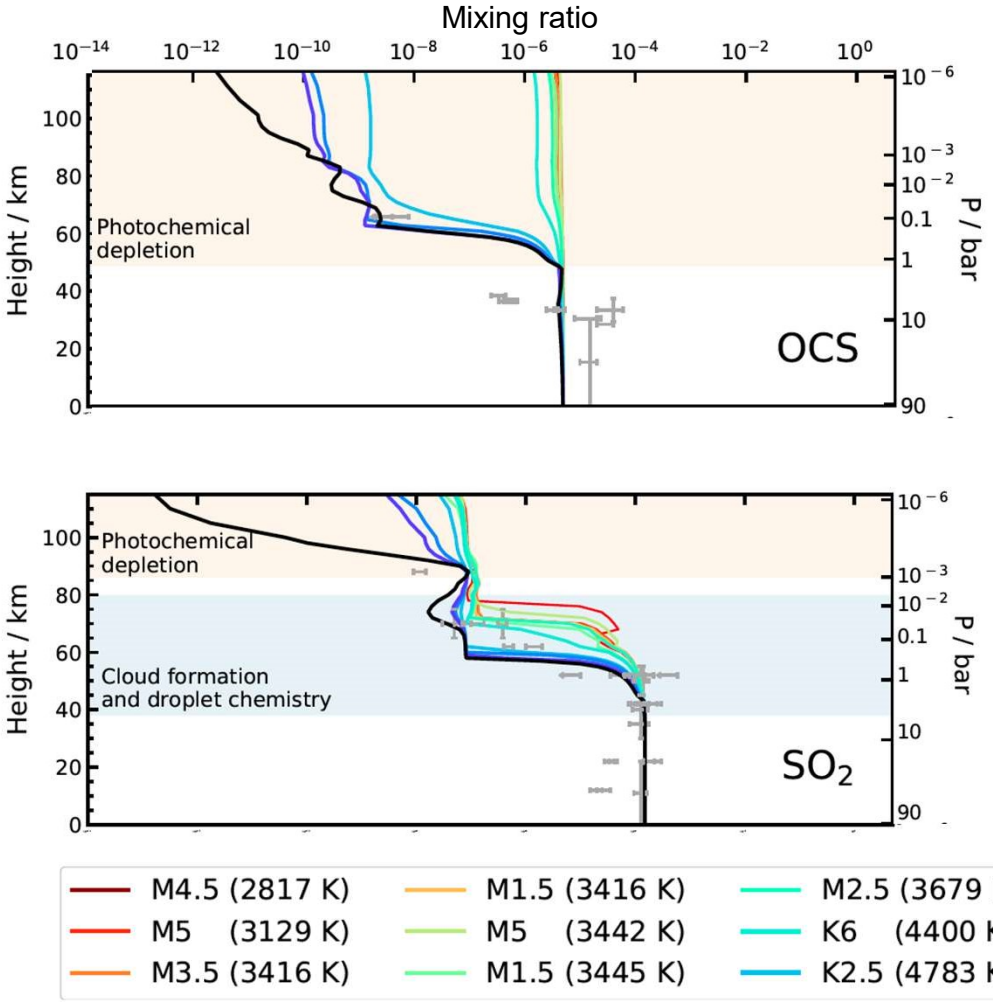


Luger & Barnes 2015

Venus helps us define the boundaries of habitability: Venuses in the “Habitable zone”??



What are the processes that can frustrate or maintain habitability?



Venus data provides ground-truth to improve models of **Exo-Venuses** that may be observed

Jordan et al. 2021