Portfolio zum Thema Exoplaneten

im Rahmen der eigenverantwortlichen Arbeit im Fach Physik

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Inhaltsverzeichnis

Beschreibung der Arbeit

Zu Beginn wurde mir der Bereich 'Bedingungen für Leben, Habitable Zone' zugewiesen, da ich keine Präferenzen angab.

Als erstes nutzte ich die Wikipedia Einträge um mir einen Überblick über das Theme zu verschaffen. Anschließend fand ich mittels https://scholar.google.com/ verschiedene wissenschaftliche Arbeiten zur habitablen Zone. Ich wählte die Arbeit "A More Comprehensive Habitable Zone for Finding Life on Other Planets" von R.M. Ramirez aus, welche 2018 in Geosciences erschienen ist aus und verbrachte die restliche Zeit der Quellensichtung damit, diese zu lesen und zu verstehen.

Bezüglich der Präsentation entschied mich dazu meinen Vortrag mittels einer Power-Point zu strukturieren. Ich erstellte meinen Teil des Handouts und fügte die Teile der Gruppenmitglieder zu meinem hinzu. Dabei kürzte ich den Inhalt auf eine DIN A4 Seite.

Quellenverzeichnis

https://en.wikipedia.org/wiki/Exoplanet - 24/12/13 - 8:00

https://www.mdpi.com/2076-3263/8/8/280 - 24/12/13 - 8:35

https://en.wikipedia.org/wiki/Habitable_zone - 24/12/13 - 8:05

Wikipedia

Definition

Bereich um einen Stern, in dem Wasser im flüssigen Zustand existieren kann

- unterschiedlich für jeden Stern
- Einflussfaktoren:
  - Hitzeausstrahlung des Sterns
  - Eigenschaften einer möglichen Atmosphäre
  - Geologische Eigenschaften eines Planeten:
    - Gestein vs Eis im Bezug auf Reflexion
  - Masse des Sterns
  - Rotationsrate des Planeten(beeinflusst Wolkenart):

- je langsamer, desto dicker die Wolken -> mehr Reflexion
- je schneller, desto dünner die Wolken -> weniger Reflexion
  -> Erde würde mit Venus T in Venus Orbit habitabel sein

> **Superhabitable planeten**
>
> Generelle Annahme: Planeten mit $m_p > m_E$ könnten lebensfreundlicher als die Erde sein

Anzeichen für Bewohnbarkeit

- Wasserdampf
- freier Sauerstoff

A More Comprehensive Habitable Zone for Finding Life on Other Planets

Link: https://www.mdpi.com/2076-3263/8/8/280

> (Artikel, S.1)
>
> The habitable zone (HZ) is the circular region around a star (or multiple stars) where standing bodies of liquid water could exist on the surface of a rocky planet

> (Artikel, S.1)
>
> it(The habitable Zone) remains the most useful roadmap for targeting potentially habitable worlds

> (Artikel, S.1)
>
> As suggested recently [Ramirez, R.M.; Kaltenegger, L. A Methane Extension to the Classical Habitable Zone. Astrophys. J. 2018, 858, 72.], the addition of the phrase "standing bodies of water" to the HZ definition emphasizes that habitable zone planets incapable of supporting more than seasonal trickles of surface water, like Mars, should not be considered for follow-up astrobiological observations. This is because any life residing within such small amounts of water would be unlikely to modify the atmosphere in a detectable manner

(Artikel, S.2)

critical point of water (647 K), which is the highest possible temperature for surface water to exist in liquid form on a rocky planet with an Earth-like inventory [Goldblatt, C.; Robinson, T.D.; Zahnle, K.J.; Crisp, D. Low simulated radiation limit for runaway greenhouse climates. Nat. Geisci. 2013, 6, 661–667, Kasting, J.; Whitmire, D.; Raynolds, R. Habitable Zones around Main Sequence Stars. Icarus 1993, 101, 108–128]

(Artikel, S.2)

The classical HZ posits that CO2 and H2O are the most important greenhouse gases for habitable planets throughout the universe.

(Artikel, S.2)

“Complex life” includes advanced life forms like animals, higher plants, and (possibly) even intelligence

(Artikel, S.2)

Kasting et al. [Kasting, J.; Whitmire, D.; Raynolds, R. Habitable Zones around Main Sequence Stars. Icarus 1993, 101, 108–128] explicitly mention that the HZ is designed to also find habitable planets that may be unsuitable for humans.

(Artikel, S.2)

classical HZ definition is concerned with carbon-based life

(Artikel, S.3)

all known life requires liquid water to survive.

(Artikel, S.3)

The effective stellar flux (SEFF) is a key quantity used in HZ calculations and is defined as the normalized flux required to maintain a given surface temperature

(Artikel, S.3)

The inner edge boundaries are not calculated using the boiling point of water.

(Artikel, S.36)

> The HZ can be utilized to rank potentially habitable planets in the habitable zone and is even capable of filtering out HZ worlds that are least likely to host life.

> (Artikel, S.31)
>
> HZ can only search for “Earth-like” life or “life as we know it”

> (Artikel, S.31)
>
> “Earth-like” is a vague and commonly-used term with no consensus as to what it means nor to what degree a planet can differ from the Earth and still be considered Earth-like (alternate terms include “habitable planets” or “potentially habitable planets”).

> (paper, p.5)
>
> Plate tectonics is thought to regulate the carbonate–silicate cycle, which maintains habitability on the Earth over billion-year-long timescales [33,34

> (paper, p.5)
>
> If it were not for this cycle, it is thought that the HZ would be much narrower, with Earth’s surface freezing if it moved out past ~1.05 AU (e.g., [7,36]).

> (paper, p.6)
>
> However, this limit had been abandoned as subsequent work found that CO2 clouds generally warm planets, even if the warming is not very much [38–40].

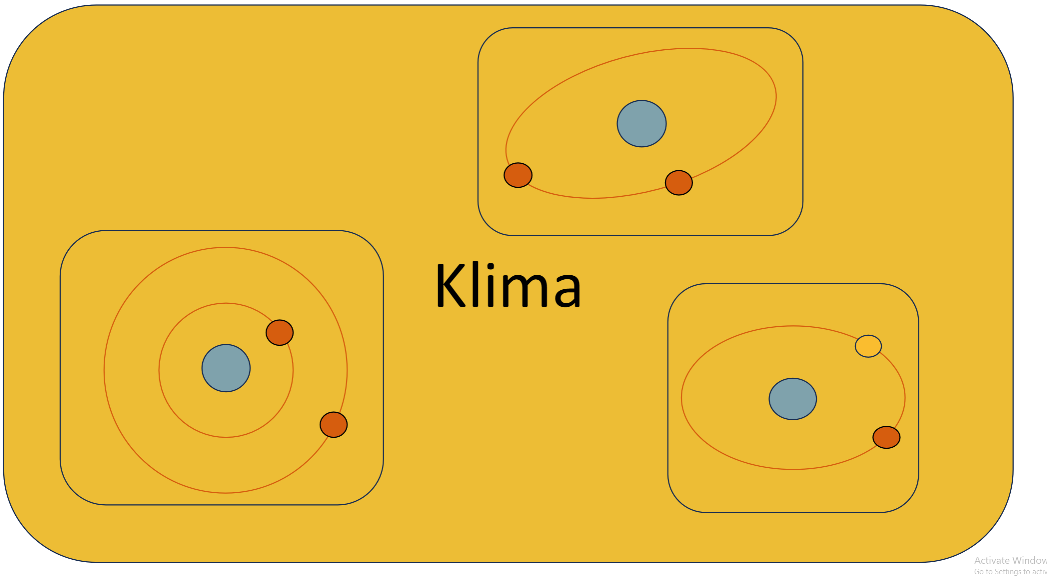
> (paper, p.7)
>
> The inner edge of the HZ has likely been past Venus’ orbital distance (~0.72 AU) for at least the past several hundred million years, possibly 1 billion years [1]. Thus, Venus could have been in a moist or runaway greenhouse state for a comparable (if not longer) amount of time, which would have depleted any hypothetical surface ocean. According to this idea, as the planet desiccates, weathering reactions slow down and the water incorporated within subducting plates decreases. This causes the plates to become too brittle for subduction and plate tectonics ceases.

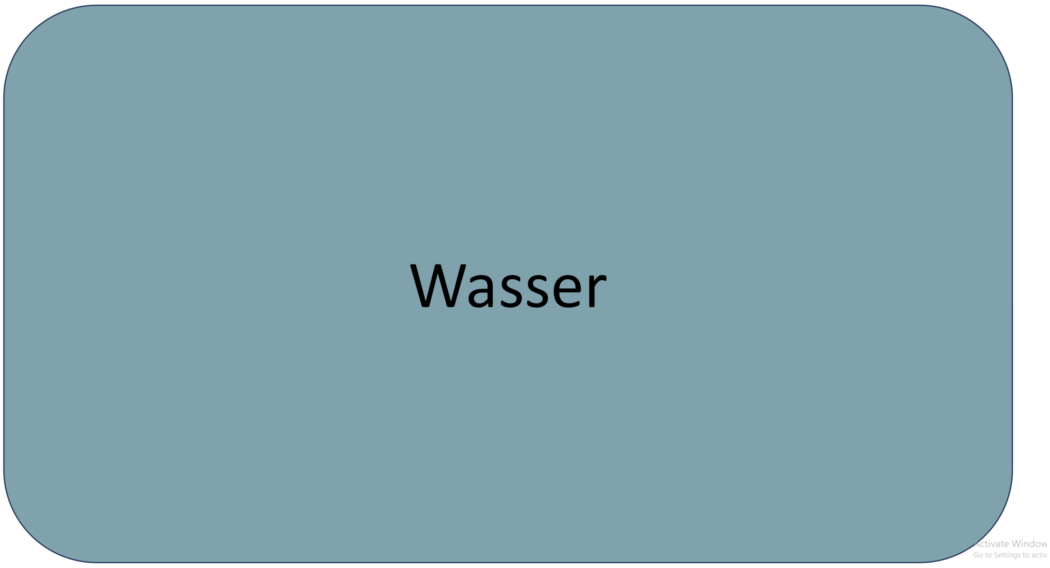
> (paper, p.11)

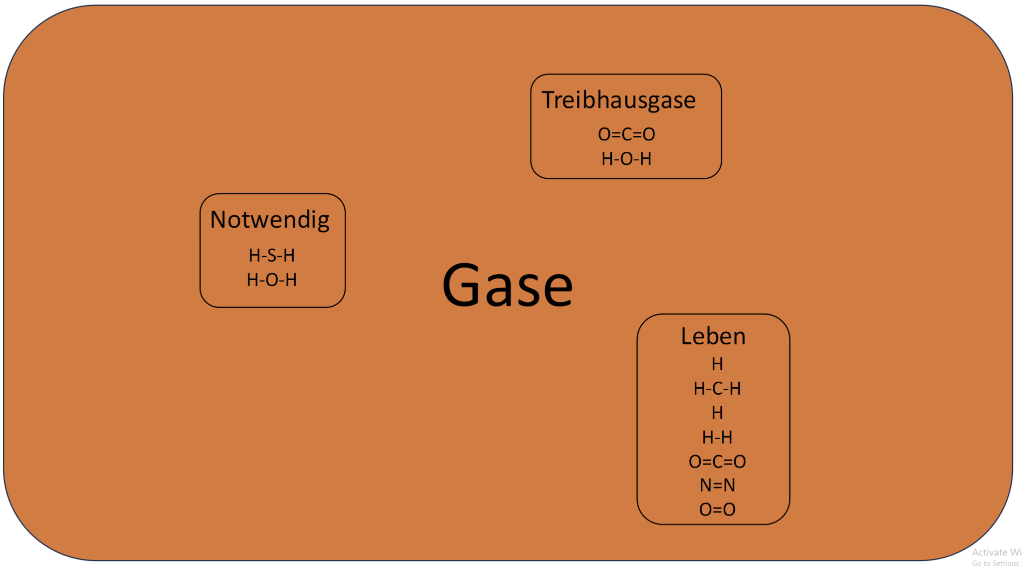
> Biotic oxygen production rates on Earth far exceed abiotic ones, suggesting that high atmospheric oxygen concentrations, perhaps in conjunction with CH4, may be good bioindicators (e.g., [106,111,112]).

Präsentation

Folien

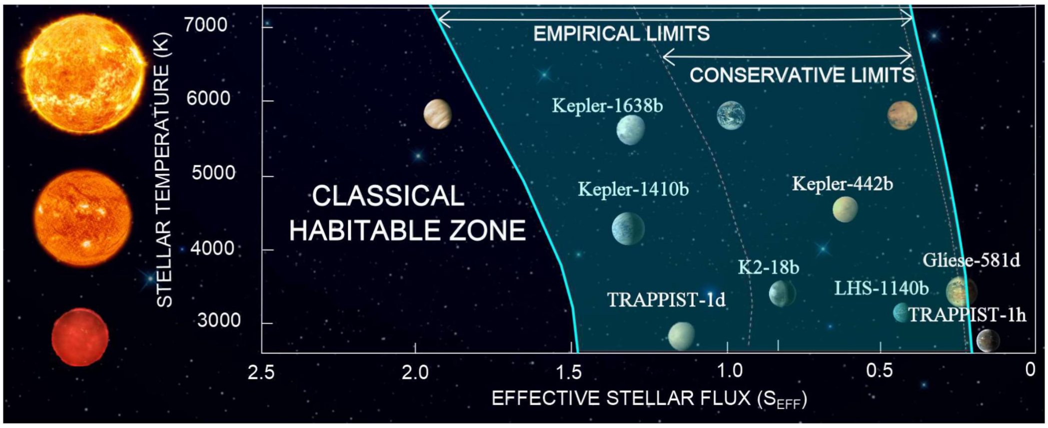


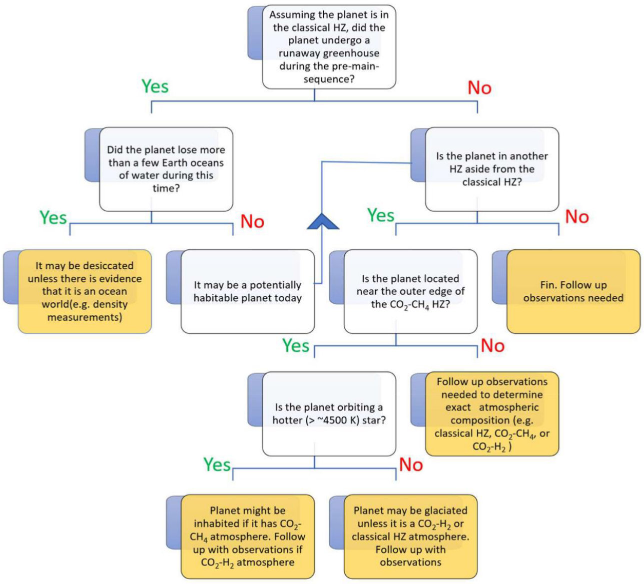


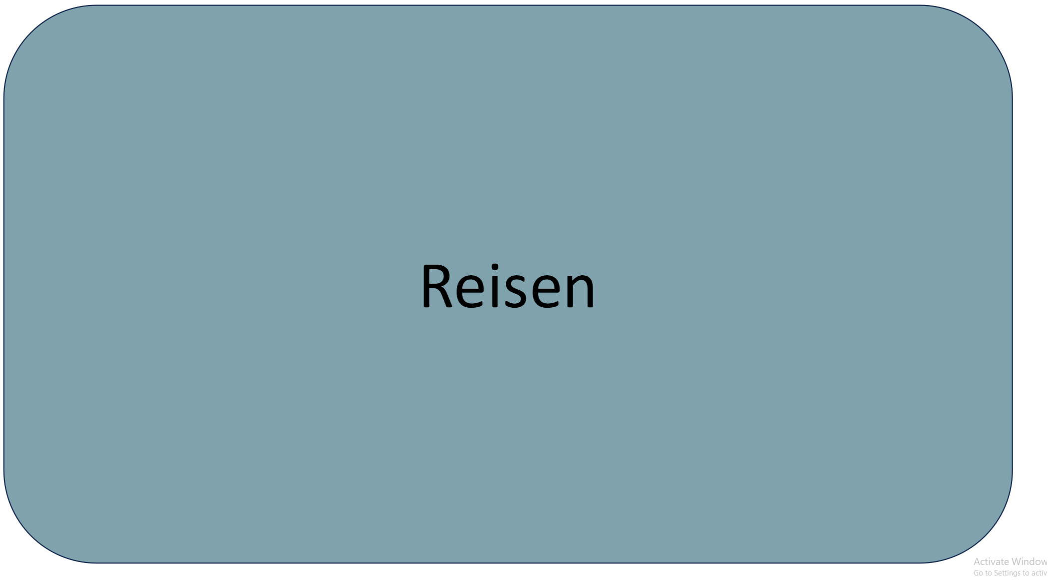


Die Habitable Zone

Region um einen Stern, in welcher Wasser in fluessiger Form auf einem steinigen Planeten existieren kann


7000
6000
5000
4000
3000
STELLAR TEMPERATURE (K)
EMPIRICAL LIMITS
CONSERVATIVE LIMITS
Kepler-1638b
CLASSICAL
HABITABLE ZONE
Kepler-1410b
Kepler-442b
K2-18b
Gliese-581d
LHS-1140b
TRAPPIST-1d
TRAPPIST-1h
2.5
2.0
1.5
1.0
0.5
0
EFFECTIVE STELLAR FLUX (S_{EFF})


Assuming the planet is in the classical HZ, did the planet undergo a runaway greenhouse during the pre-main-sequence?
Yes
No
Did the planet lose more than a few Earth oceans of water during this time?
Is the planet in another HZ aside from the classical HZ?
Yes
No
Yes
No
It may be desiccated unless there is evidence that it is an ocean world(e.g. density measurements)
It may be a potentially habitable planet today
Is the planet located near the outer edge of the CO_2-CH_4 HZ?
Fin. Follow up observations needed
Yes
No
Is the planet orbiting a hotter (> ~4500 K) star?
Follow up observations needed to determine exact atmospheric composition (e.g. classical HZ, CO_2-CH_4, or CO_2-H_2)
Yes
No
Planet might be inhabited if it has CO_2-CH_4 atmosphere. Follow up with observations if CO_2-H_2 atmosphere
Planet may be glaciated unless it is a CO_2-H_2 or classical HZ atmosphere. Follow up with observations



Handout

Bedingungen für extraterrestrisches Leben

1. **Klima** - Einflussfaktoren
    1. Distanz zum Stern
    2. Exzentrizität der elliptischen Umlaufbahn
    3. Atmosphärische Eigenschaften
2. **Wasser**
    1. Muss in **flüssiger** Form vorliegen
3. **Gase**
    1. **Notwendig**: H_2O, H_2S
    2. **Treibhausgase** für Temperaturregulierung
    3. Bestimmte Gase je nach Lebensform

Kontakt

[...]

- **Reisen** bis jetzt technisch weit entfernt von umsetzbar in fast allen Aspekten