Quantifying the Habitability of Rocky, Earth-like Exoplanets Using Three-Dimensional General Circulation Models

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How do insolation and day length impact habitability?

Introduction

We attempted to calculate *habitability fractions* for 70 of the simulations from Way et al. (2018). [5]

Way et al. (2018):

Earth-like planets with varying *stellar insolations* and *sidereal day lengths*.

Using the ROCKE-3D GCM.

Vocabulary

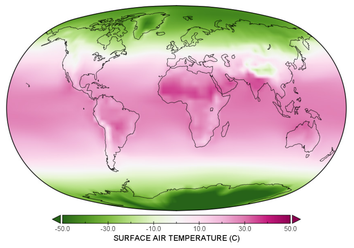
Habitability Fraction: The fraction of a planet's surface or volume that can support liquid water.

Stellar Insolation: The flux of stellar radiation per unit area on a planet's surface.

Sidereal Day Length: The time it takes a planet to complete one rotation, relative to the background stars.

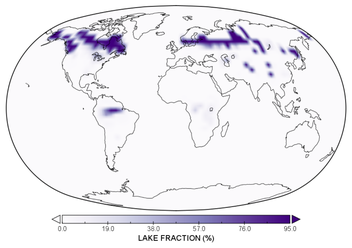
General Circulation Model (GCM): A model that simulates the circulation of a planet's atmosphere and/or ocean.

Temperature



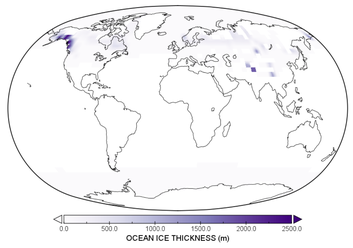
- Life as we know it needs liquid water to survive. [3]
- Here, only temperatures between 0 and 100°C are considered habitable.
- These simulations do not account for scenarios where high pressure or salinity could allow for a broader liquid temperature range.

Water Availability

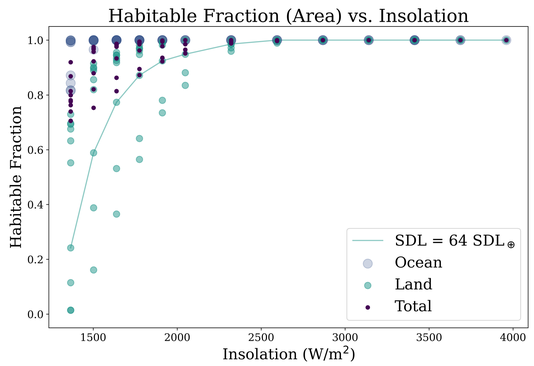


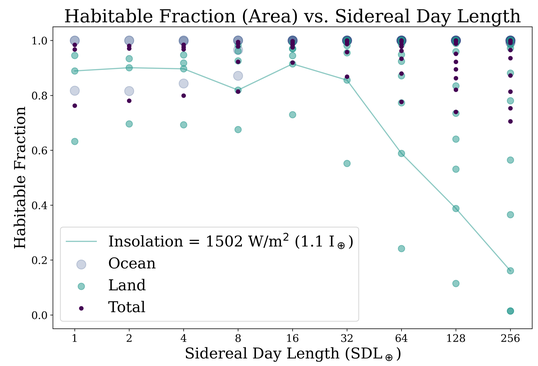
- Again, life as we know it needs water to survive.
- Yet, even in the driest places on Earth, we have still found evidence of life. [6, 1]
- Water availability was calculated using ground water and ice, but did not include lakes as an additional source. [2]

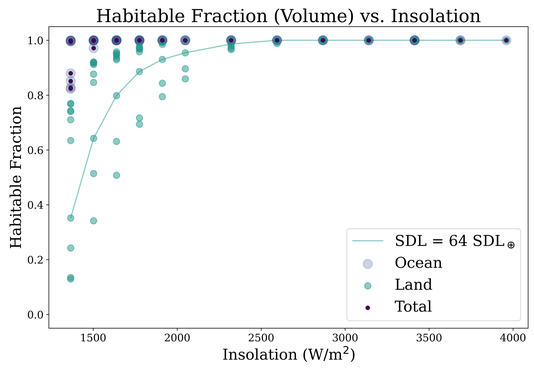
Ice Fraction

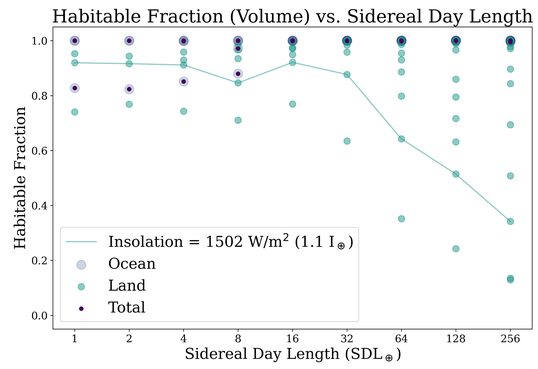


- Our model gives us the freeboard (above water) ice thicknesses. [4]
- The draft (below water) ice thickness is always around 9 times the freeboard. [4]
- Ice is not considered to be habitable, so we must calculate and subtract the draft ice volume from the total ocean volume.









Conclusion

Insolation ↑, Habitability ↑

Day Length ↑, Habitability ↓

In the future, it may prove insightful to adapt ROCKE-3D to handle higher insolation values, or to experiment with the impact that high pressures and salinities have on habitability.

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References

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