Why is planet Earth so habitable?

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Life on Earth as a planetary feature is so obvious that it would be hard to miss for an alien to detect Earth as being habitable. Why is this so? Here I use a perspective of Earth system functioning and non-equilibrium thermodynamics to address this question. I start with Schrödinger's fundamental notion [1] that life is maintained by dissipating sources of free energy, thereby producing high entropy waste. Planetary habitability from this perspective becomes a question of non-equilibrium thermodynamics: Why is life on Earth able to dissipate so much energy? And this is a question about the unique aspects of Earth's climatic environment and why life would emerge as a predictable set of biogeochemical processes within that system. A unique thermodynamic feature of Earth is that the amount of absorbed sunlight – and thereby the source of free energy for most of the dissipative activity of the Earth's biosphere – is not externally determined by the incoming flux of solar radiation, but rather strongly modulated internally within the climate system, especially through the location and amount of clouds and ice. I argue that by modulating climate system interactions that involve the strength of the greenhouse effect, clouds, and the extent of ice, the addition of life allows the Earth system to evolve to states of overall higher levels of entropy production [2]. Life is then simply an implementation of the thermodynamic principle of Maximum Entropy Production (MEP, [3-5]) at the planetary level. The extent to which a planet is habitable is then directly related to the extent to which planetary boundary conditions – essentially the planetary albedo – can be modified such that planetary entropy production is maximized under the given constraints of incoming solar radiation and climate system functioning. I use model simulations of the climate system to illustrate this line of reasoning.

References:

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