Understanding habitability on the pathways to habitable planets

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Abstract

While we develop the observation tools that will, someday, characterize habitable planets, the concept of habitability is regularly challenged. It not easy to define life and what is needed for it, so drawing a line between "habitable" and "not-habitable" is difficult. We usually postulate that "habitable = liquid water available" because liquid water seems required for life as we can imagine it. However, worlds with liquid water can be seen as more or less habitable, depending on 1) the available molecules and energy sources (notably light), 2) the time available for life to emerge and evolve. Different class of habitability can be defined, ranging, from worlds with liquid water only in the deep interior, to Earth-like cases with surface liquid water enabling photosynthetic life to modify the atmosphere in a detectable way. Within that context, we can agree to define the "Habitable zone" as the region outside which it is impossible for a rocky planet to maintain liquid water on its surface. Even this is not without ambiguity, since "exotic" configuration (e.g. a thick H2-rich atmosphere) can extend the habitable zone beyond what could be estimated assuming an "expected" terrestrial atmosphere composition. But what atmospheres can we expect? Which processes control their evolution? These are the key questions. Our solar system experience is too limited and observations are needed. Much can be learned even by characterizing atmospheres outside the habitable zone.

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