Search for habitable planets should be more conservative

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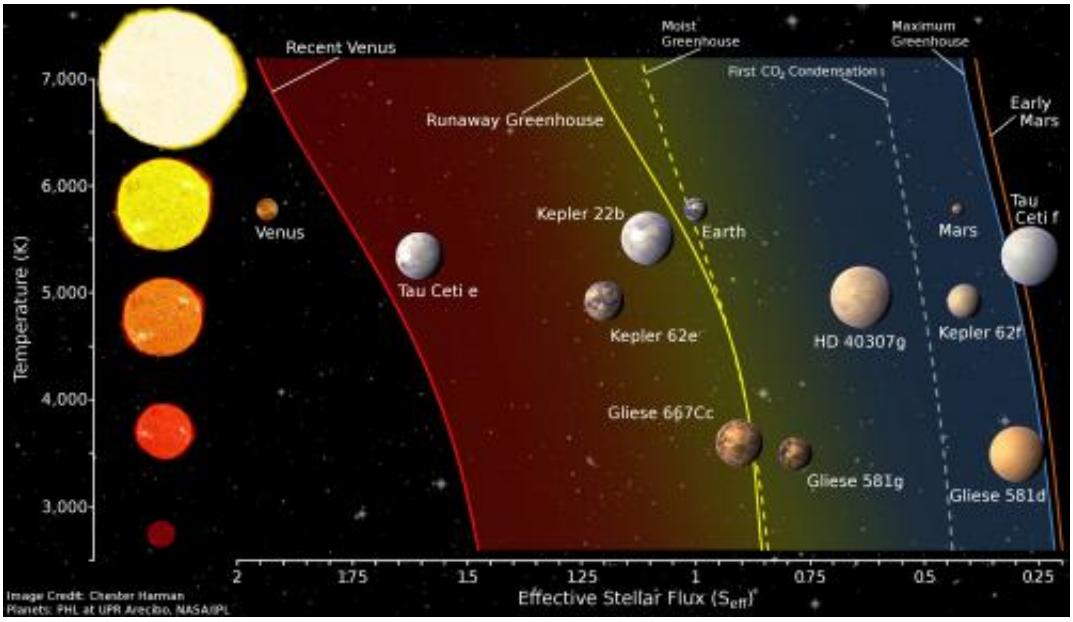

This chart shows star temperatures vs. stellar flux showing various zones including Earth. Credit: Chester Harmon

Scientists should take the conservative approach when searching for habitable zones where life-sustaining planets might exist, according to James Kasting, Evan Pugh Professor of Geosciences at Penn State, including when building Terrestrial Planet Finders.

That conservative approach means looking for planets that have liquid water and solid or liquid surfaces, as opposed to gas giants like Jupiter or

Saturn. The habitable zone in a solar system is the area where liquid water, and by extension life, could exist. Defining the habitable zone is key to the search for life sustaining planets in part because the idea of a habitable zone is used in designing the space-based telescopes that scientists would use to find planets where metabolism—and potentially life—life might exist.

"It's one of the biggest and oldest questions that science has tried to investigate: is there life off the earth?" Kasting said. "NASA is pursuing the search for life elsewhere in the Solar System, but some of us think that looking for life on planets around other stars may actually be the best way to answer this question."

Recent research by Ravi Kopparapu, a post-doctoral researcher working with Kasting, suggests that the frequency of Earth-like planets in the habitable zones of stars known as M-dwarfs is 0.4 to 0.5. To find four potential Earth-like candidates, scientists would need to survey the habitable zones of about 10 cool stars. This data came from NASA's Kepler Space Telescope, which collected information on transiting exoplanets for almost four years before being partially disabled. Previous estimates put this frequency at 0.1, which would have forced scientists using planet finders to survey more stars, searching farther away from our Solar System.

An even more recent estimate of the frequency of Earth-like planets was announced by Eric Petigura and colleagues at the Kepler Science Conference in early November. They calculated the figure at 0.22 around stars more similar to the Sun. But Kopparapu and Kasting think Petigura and colleagues' estimate could be too high by a factor of two because they used an overly optimistic estimate for the width of the habitable zone. If so, then the old value of 0.1 may be closer to the truth.

The ability of a planet to sustain liquid water is traditionally part of the

criteria when searching for life-sustaining planets. While some have argued that subsurface water would be enough to sustain life, testing that hypothesis remotely would be virtually impossible, so the focus for astronomers should remain on surface water, Kopparapu and Kasting note in a special issue of the *Proceedings of the National Academy of Sciences*.

"All life that we know of is carbon-based and depends on the presence of liquid water during at least part of its life cycle," Kasting notes in the paper. "Hence, if we see a planet that shows evidence for liquid water, we can immediately think about the possible presence of carbon-based life."

While no federal funding to build a Terrestrial Planet Finder is currently in place, the amount of research related to exoplanets is strengthening. A TPF would allow for the detection of gases—or lack thereof—in planets' atmospheres. If, for example, no signs of life are found after searching the habitable zones of 30 stars, that could be a reason for pessimism, said Kasting, who is also part of Penn State's Earth and Environmental Systems Institute.

And, while it may be more appealing to know that there is evidence of life on other planets, learning that there is not would have scientific implications.

"Maybe every planet out there that has the right conditions develops life," Kasting said. "We don't really know the answer to that. But, it could be. If you're an optimist, you think it just takes the right conditions. It happened on Earth, why wouldn't it happen somewhere else?"

It is possible that initial observations of Earth-like exoplanets could give an ambiguous answer, Kasting added. For example, oxygen might be

found, but not methane. But even that could open the door to further exploration.

While the pursuit of life in the outer reaches of the sky might seem far-fetched at first glance, Kasting noted that astronomers have talked about it as a second Copernican revolution.

"Did it make any difference when we figured out that the Earth was going around the sun rather than vice versa? If you're just a practical-minded person, it made absolutely no difference to your life because life goes on Earth just the way it did," Kasting said.

"But if you expand your mind a little bit, it helped us figure out our place in the universe—that we're actually on a little planet going around a rather normal star amongst many other stars in the galaxy, and there are many galaxies out there. It's been one of the most profound changes ever in human thought. We think of TPF as the next step in the Copernican revolution, to figure out if there are other Earths out there and if there is life on those planets."

More information: Remote life-detection criteria, habitable zone boundaries, and the frequency of Earth-like planets around M and late K stars, www.pnas.org/cgi/doi/10.1073/pnas.1309107110

Provided by Pennsylvania State University

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