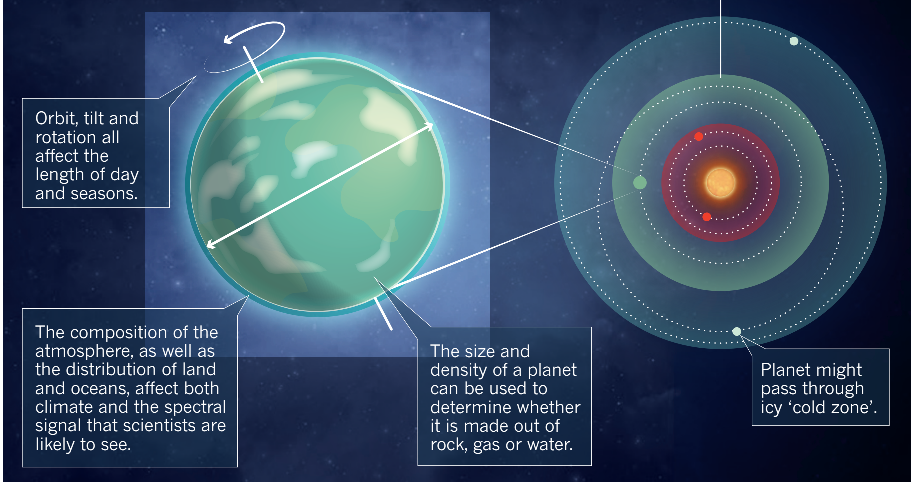
RECIPE FOR A HABITABLE PLANET

The search for life beyond Earth focuses on the 'habitable zone', where conditions allow for liquid surface water. Whether a planet can support life depends on the distance to its star, that star's energy, and the planet's size and composition. Scientists have confirmed at least five planets that are less than twice the size of Earth and sit in the habitable zones of their stars.



PLANETARY SCIENCE

Climate scientists eye alien worlds

NASA initiative seeks to bolster interdisciplinary science in the search for life beyond Earth.

BY JEFF TOLLEFSON

The hunt for life beyond the Solar System is gaining new partners: NASA climatologists. After more than 30 years of studying Earth, a team at the NASA Goddard Institute for Space Studies (GISS) in New York will adapt its global climate model to simulate conditions on potentially habitable exoplanets. The effort is part of a broader push to identify Earth-like worlds that NASA will launch on 20 April at a meeting in Washington DC.

Already, the agency's space-based Kepler telescope has pinpointed more than 1,000 alien planets by observing the brief interruption of starlight that signals a planet passing in front of its parent star. At least five of these planets are similar in size to Earth and located in the 'habitable zone', where liquid water could persist. The next step would be to detect light passing through exoplanet atmospheres, which could hold clues to conditions on these distant worlds.

"We have to start thinking about these things as more than planetary objects," says Anthony Del Genio, a climate modeller who is leading the GISS effort. "All of a sudden, this has become a topic not just for astronomers, but for planetary scientists and now climate scientists."

Del Genio's group is one of around 16 — ranging from Earth and planetary scientists to solar physicists and astrophysicists — that are participating in NASA's new Nexus for Exoplanet System Science (NExSS) programme. The effort has an initial annual budget of roughly US$10 million to $12 million.

"We are bringing together a bunch of different disciplines, and they all look at the formation and functioning of planets in different ways," says Mary Voytek, who directs NASA's astrobiology programme and organized NExSS. Although interest is high, Voytek says, communication remains a challenge. "You can't even get these communities to agree on a definition of the habitable zone."

The initiative is based in part on the Virtual Planetary Laboratory at the University of Washington in Seattle, which launched in 2001 and now has 55 researchers from 23 institutions collaborating on interdisciplinary exoplanet research. "When we started this, people thought we were crazy," says Victoria Meadows, an astronomer and the project's principal investigator. "But this is not something that a single discipline can address."

NExSS will expand the network of researchers collaborating on exoplanets, she says. That should help scientists to make sense of existing data and observations from the James Webb Space Telescope and the Transiting Exoplanet Survey Satellite, which are both scheduled for launch in 2018. It could also help NASA develop missions to hunt for exoplanets in the 2020s and beyond.

At GISS, Del Genio's team has already started repurposing the institution's workhorse Earth-system climate model. The researchers are combing through its source code to locate simple parameters that are fixed for Earth, such as 24-hour days and 365-day orbits, in order to create an exoplanet model that can be adjusted for different planetary systems. Initial simulations will focus on Earth's ancient past and the evolution of Mars and Venus. Although neither can support life today, each may have had liquid surface water at some time.

The GISS team's ultimate goal is to explore the concept of a habitable zone by mixing and matching some of the key factors that determine whether a planet can support life (see 'Recipe for a habitable planet'). By feeding these parameters into the exoplanet model, the group will create a database of 'hypothetical atmospheres' with spectra that could be visible to astronomers.

Del Genio's group is one of several that are using climate models in exoplanet research. A group led by physicist François Forget at the Pierre Simon Laplace Institute in Paris used such a model to explore the runaway warming that occurs when water vapour builds up in a planet's atmosphere, trapping outgoing radiation. In December 2013, they reported in *Nature*[1] that the early Earth could withstand more solar radiation before its oceans boiled off than scientists had thought. Two other groups have done similar experiments[2,3], and Del Genio says that his team is exploring the same issue.

The 3D models could be particularly useful for defining the habitable zone, and the place to start is the Solar System, says James Kasting, an atmospheric scientist at Pennsylvania State University in University Park who works on one-dimensional exoplanet models. But ultimately, he adds, progress will depend on better observations of exoplanets.

"In 15 or 20 years, we might get a spectrum of a planet that looks Earth-like, and then everyone will be out with their models trying to model that planet," he says. "I would like it to happen quicker — but we need a big telescope." ■

1. Leconte, J. *et al. Nature* **504,** 268–271 (2013).
2. Yang, J., Cowan, N. B. & Abbot, D. S. *Astrophys. J.* **771,** L45 (2013).
3. Wolf, E. T. & Toon, O. B. *Geophys. Res. Lett.* **41,** 167–172 (2014).