Eos
VOL. 102 | NO. 2
FEBRUARY 2021
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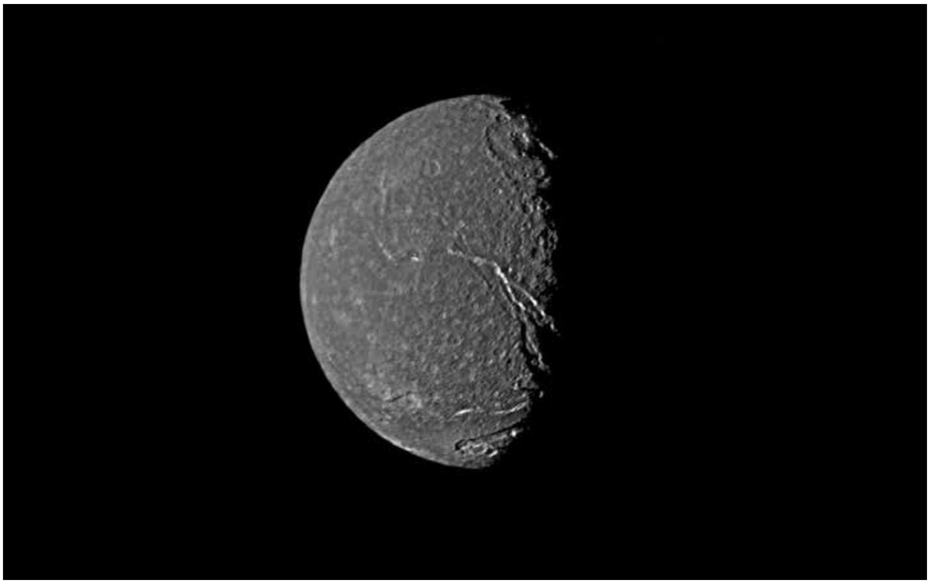
Do Uranus's Moons Have Subsurface Oceans?



"The moon methinks looks with a watery eye." —Titania, A Midsummer Night's Dream, *William Shakespeare. Above, Uranus's moon Titania as seen by Voyager 2 in 1986. Credit: NASA/JPL*

The solar system is rife with tiny, icy worlds. Many of them are moons of the gas giant planets and have been confirmed or are suspected to have liquid oceans beneath frozen ice shells. Jupiter's moon Europa and Saturn's moon Enceladus are two of the more famous examples of such worlds. Why wouldn't some of the moons of Uranus and Neptune, the solar system's ice giant planets, have subsurface oceans too?

Most planetary scientists agree that there's no reason why not, and a team of researchers found that a tried-and-true method of confirming the existence of subsurface oceans would work especially well for the moons of Uranus.

"The big question here is, Where are habitable environments in the solar system?" said Benjamin Weiss, a planetary scientist at the Massachusetts Institute of Technology in Cambridge. The discoveries of oceans on Europa and Enceladus "make a lot of us wonder whether there are many moons out there that although they're small, may still be warm." Weiss presented this research in December at AGU's Fall Meeting 2020 (bit.ly/moon-oceans).

Ocean Currents

During Voyager 2's flyby of the Uranus system in 1986, it sent back to Earth the first (and so far only) close-up views of the planet's five largest moons—Miranda, Ariel, Umbriel, Titania, and Oberon. Those images revealed that the moons are made up of a roughly 50:50 combination of rock and ices and, like most planetary satellites, have many craters. However, the moons' surfaces also display some of the classic signs of cryovolcanism, like fresh uncratered material and ridges, valleys, and folds.

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As with Europa and Enceladus, a subsurface ocean is one way those signs of recent geologic activity could have been created. Weiss and his team wanted to know whether a future spacecraft could discover such an ocean.

The researchers calculated the strength of the magnetic field Uranus would induce on a moon's hypothetical subsurface ocean and determined whether a future mission orbiting the planet would be able to detect that induced field. This is the same technique scientists with NASA's Galileo mission used in 1998 to confirm the presence of a subsurface ocean on Jupiter's moons Europa and Callisto.

An induced magnetic field works like this: As a moon orbits a planet, it also travels through the planet's magnetic field, which isn't the same strength or direction everywhere. The moon "feels" a changing magnetic field, a process that generates an electrical current. "If there's liquid water there and it's a little bit salty like ocean water on the Earth, then it can be conducting, meaning currents can flow in it," Weiss said. That flowing current will, in turn, generate its own magnetic field—an induced magnetic field. An induced field looks very different from a planet's magnetic field and so can be detected by a nearby magnetometer.

Using theoretical models of Uranus's magnetic field, Weiss's team calculated the strengths of the fields induced on Miranda, Ariel, Umbriel, Titania, and Oberon and found that Miranda's induced magnetic field was the strongest, at 300 nanoteslas, and Oberon's was the weakest, at just 3 nanoteslas. For comparison, the Galileo mission measured an induced magnetic field of about 220 nanoteslas at Europa and about 40 nanoteslas at Callisto. A subsurface ocean on Miranda, Ariel, Umbriel, and Titania would be well within the measurement capabilities of current spacecraft technology, Weiss said, although Oberon's field might be right on the edge of detectability.

Strength in Strangeness

Uranus's magnetic field, like so much about the planet itself, is quite odd compared with those of other solar system planets: The field is tilted by 59° from the planet's spin axis, and its center is shifted from the planet's center by about a third of the planet's radius.

Magnetic induction confirmed the presence of Europa's and Callisto's subsurface oceans, but Jupiter's very symmetric magnetic field made it impossible for the Galileo mission to figure out the oceans' depth, thickness, or salinity with its small number of flybys. The same is true of Saturn's magnetic field and Enceladus's subsurface ocean. But measurements of those properties might be possible for moons of Uranus.

"The key is that Uranus' field is non-spin symmetric, unlike Saturn's, and it rotates. We know these things, so [the technique] should work," said David Stevenson, a planetary scientist at the California Institute of Technology in Pasadena and a member of the Galileo team. Stevenson was not involved with this research. "The caveat is magnetospheric effects [of Uranus], which are not yet well characterized but are unlikely to kill the idea."

Detecting a signal would be "actually easier and more reliable" than other methods that might find an ocean.

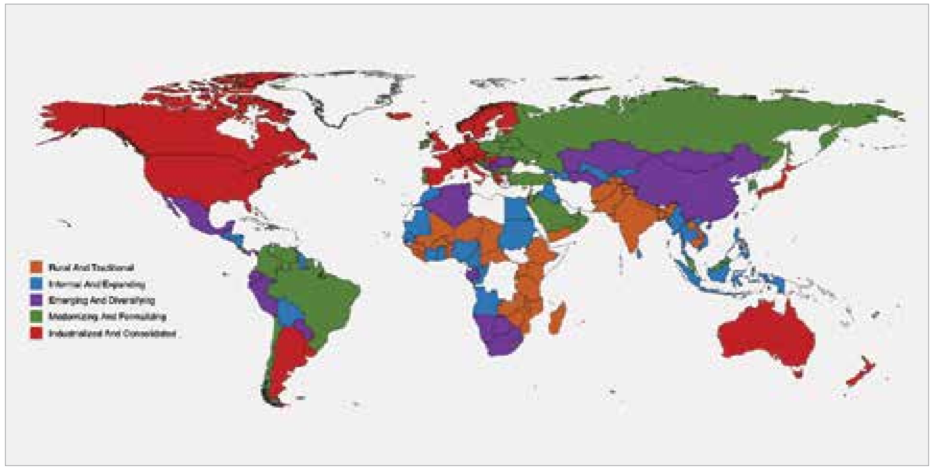
However, Stevenson cautioned, subsurface oceans in the Uranus system are likely to be farther beneath the surface than those in the Jupiter system simply because Uranus's moons are colder and so the icy shell is likely thicker. Although that might make the measured field weaker than estimated, he said, detecting a signal would be "actually easier and more reliable" than other methods that might find an ocean.

Uranus and Neptune are higher-priority targets for a spacecraft mission than they have been in the past because an opportune launch window opens up in the late 2020s. NASA, for example, is considering a Neptune mission called Trident, although no mission to Uranus is currently under consideration. However, "getting close enough to one or more of the satellites to see this—you have to get close, meaning within a satellite radius, roughly—is unlikely to be a feature of an early...mission to Uranus," which likely wouldn't arrive before 2042, Stevenson said.

A mission to an ice giant might be far off, Weiss admitted, but he hopes that this research "stimulates people to look even more seriously at the idea of sending a magnetometer investigation to Uranus or Neptune."

By **Kimberly M. S. Cartier** (@AstroKimCartier), Staff Writer

Food Systems Are Complicated. Food Data Don't Have to Be



A map from the Food Systems Dashboard shows different types of food systems around the world. Credit: Food Systems Dashboard, GAIN and Johns Hopkins University, 2020, Geneva, Switzerland, https://doi.org/10.36072/db

At a time when half of the fresh fruit purchased in the United States comes from other countries and sandwiches have carbon footprints, today's food landscape is giving some consumers more options.

Food systems, the webs of agricultural and commercial activities that bring food from farms to our tables, have never been so complex. This complexity impedes the work of researchers, planners, and others looking to make positive impacts on human health and the environment. A new tool developed by researchers at Johns Hopkins University and the Global Alliance for Improved Nutrition (GAIN) aims to help such decisionmakers by allowing them to distill loads of data on food systems into a Google Maps–like dashboard.

A Global Problem

Worldwide, nearly 1 in 10 people don't have enough food to eat, and 3 billion can't afford a healthful diet, according to a 2020 United Nations report (bit.ly/food-security-assessment). "The numbers are kind of scary," said Lawrence Haddad, executive director of GAIN.

Although the number of people struggling with hunger decreased between 1990 and the mid-2010s, the numbers have gone back up in recent years because of conflicts and political fragility in many parts of the world, said Haddad. Effects of climate change, such as increases in extreme weather and land degradation, aren't helping either.

At the same time, policymakers and businesses often emphasize profit over nutritionally or environmentally beneficial outcomes, said Haddad. "The system is not set up to [benefit nutrition or the environment]. It's set up to make money."

So he and his colleagues set out to create a tool for investigating agricultural, production, and distribution supply chains, as well as drivers of food systems like urbanization and gender equality, health outcomes like diet and nutrition, and other related factors. The result is a colorful online dashboard—the first to distill country-level data into one place—that lets users tinker with and explore more than 170 facets of food systems around the world (bit.ly/food-system-dashboard).

"You can't fix something that you can't measure," Haddad said. Now decisionmakers can zero in on failing parts of systems and tweak them to improve nutrition for consumers, increase crop biodiversity, or minimize greenhouse gas emissions.

How It Works

The goal of the dashboard is to make it easier for policymakers, businesspeople, and others to describe, diagnose, and enact changes in food systems.