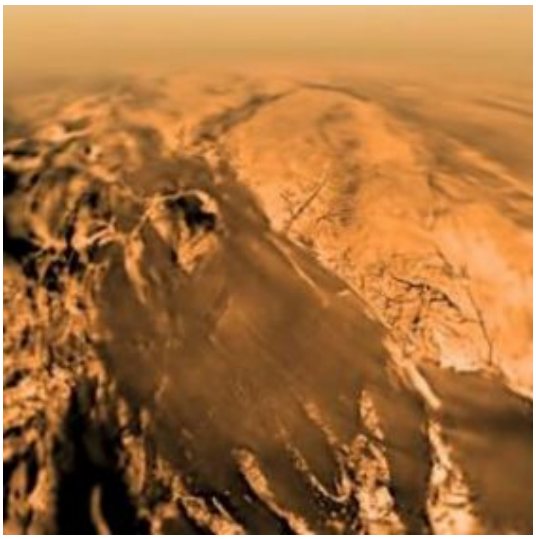
Titan's icy climate mimics Earth's tropics



This image of Titan was taken by the Descent Imager/Spectral Radiometer on board the European Space Agency's Huygens probe, on Jan. 14, 2005. It was taken looking west from 5 miles above the surface. (Credits: ESA/NASA/JPL/University of Arizona)

If space travelers ever visit Saturn's largest moon, they will find a tropical world where temperatures plunge to minus 274 degrees Fahrenheit, methane rains from the sky and dunes of ice or tar cover the planet's most arid regions. These conditions reflect a cold mirror image of Earth's tropical climate, according to scientists at the University of Chicago.

"You have all these things that are analogous to Earth. At the same time, it's foreign and unfamiliar," said Ray Pierrehumbert, the Louis Block Professor in Geophysical Sciences at Chicago.

Titan, one of Saturn's 60 moons, is the only moon in the solar system large enough to support an atmosphere. Pierrehumbert and Jonathan Mitchell, who recently completed his Ph.D. in Astronomy & Astrophysics at Chicago, have been comparing observations of Titan collected by the Cassini space probe and the Hubble Space Telescope with their own computer simulations of the moon's atmosphere.

Their study of the dynamics behind Titan's methane clouds have appeared in the Proceedings of the National Academy of Sciences. Their continuing research on Titan's climate focuses on the moon's deserts.

"One of the things that attracts me about Titan is that it has a lot of the same circulation features as Earth, but done with completely different substances that work at different temperatures," Pierrehumbert said. On Earth, for example, water forms liquid and is relatively active as a vapor in the atmosphere. But on Titan, water is a rock. "It's not more volatile on Titan than sand is on Earth."

Methane-natural gas-assumes an Earthlike role of water on Titan. It exists in enough abundance to condense into rain and form puddles on the surface within the range of temperatures that occur on Titan.

"The ironic thing on Titan is that although it's much colder than Earth, it actually acts like a super-hot Earth rather than a snowball Earth, because at Titan temperatures, methane is more volatile than water vapor is at Earth temperatures," Pierrehumbert said.

Pierrehumbert and Mitchell even go so far as to call Titan's climate tropical, even though it sounds odd for a moon that orbits Saturn more than nine times farther from the sun than Earth. Along with the behavior of methane, Titan's slow rotation rate also contributes to its tropical nature. Earth's tropical weather systems extend only to plus or minus 30 degrees of latitude from the equator. But on Titan, which rotates only once every 16 days, "the tropical weather system extends to the entire planet," Pierrehumbert said.

Titan's tropical nature means that scientists can observe the behavior of its clouds using theories they've relied upon to understand Earth's tropics, Mitchell noted.Titan's atmosphere produces an updraft where surface winds converge. This updraft lifts evaporated methane up to cooler temperatures and lower pressures, where much of it condenses and forms clouds.

"This is a well-known feature on Earth called an ITCZ, the inter-tropical convergence zone," Mitchell said. Earth's oceans help confine the ITCZ to the lowest latitudes. But in some scenarios for oceanless Titan, the ITCZ in Mitchell's computer simulations wanders in latitude almost from one pole to the other. Titan's clouds should also follow the ITCZ.

Titan's orange atmospheric haze complicates efforts to observe the moon's clouds. "This haze shrouds the entire surface," Mitchell said. "It pretty much blocks all visible light from reaching us from the surface or from the lower atmosphere."

Nevertheless, infrared observations via two narrow frequency bands have recently revealed that clouds are currently confined to the moon's southern hemisphere, which is just now emerging from its summer season.

"There should be a very large seasonality in these cloud features," Mitchell said. "Cassini and other instruments might be able to tell us about that in the next seven to 10 years or so, as the seasons progress."

Mitchell and Pierrehumbert's next paper will describe how oscillations in Titan's atmospheric circulation dry out the moon's midsection. Over the course of a year, Mitchell explained, "this oscillation in the atmosphere tends to transport moisture, or evaporated methane, out of the low latitudes and then deposit it at mid and high latitude in the form of rainfall. This is interesting, because recent Cassini observations of the surface suggest that the low latitudes are very dry."

Cassini images show dunes of ice or tar covering these low-latitude regions that correspond to the tropics on Earth. When ultraviolet light from the sun interacts with methane high in Titan's atmosphere, it creates byproducts such as ethane and hydrogen.

These byproducts become linked to chains of hydrocarbon molecules that create Titan's orange haze. When these molecules coalesce into large particles, they settle out as a tar-like rain.

"Titan is like a big petrochemical plant," Pierrehumbert said. "Although this is all happening at a much lower temperature than in a petroleum refinery, the basic processes going on there are very closely allied to what people do when they make fuel."

Source: University of Chicago