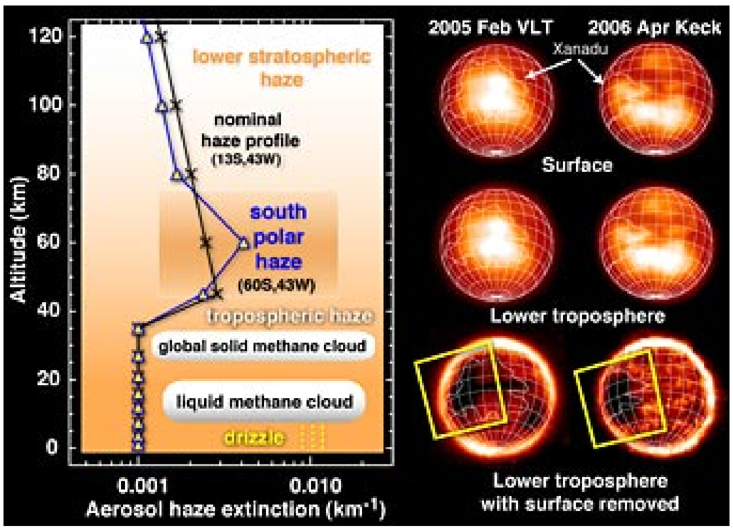
Methane drizzle on Saturn's moon Titan

October 11 2007



VLT and Keck near-infrared images of Titan's surface and lower troposphere can be subtracted to reveal widespread cirrus-like clouds of frozen methane (lower images) and a large patch of liquid methane (dark area within box) interpreted as clouds and morning drizzle above the huge continent of Xanadu (outline). At left is a chart of Titan's aerosol haze versus altitude, indicating higher density haze over portions of the south pole and the heights of frozen and liquid methane clouds. (Mate Adamkovics/UC Berkeley, W. M. Keck Observatories, ESO)

Noted for its bizarre hydrocarbon lakes and frozen methane clouds, Saturn's largest moon, Titan, also appears to have widespread drizzles of methane, according to a team of astronomers at the University of California, Berkeley.

New near-infrared images from Hawaii's W. M. Keck Observatory and Chile's Very Large Telescope show for the first time a nearly global cloud cover at high elevations and, dreary as it may seem, a widespread and persistent morning drizzle of methane over the western foothills of Titan's major continent, Xanadu.

In most of the Keck and VLT images, liquid methane clouds and drizzle appear at the morning edge of Titan, the arc of the moon that has just rotated into the light of the sun.

"Titan's topography could be causing this drizzle," said Imke de Pater, UC Berkeley professor of astronomy. "The rain could be caused by processes similar to those on Earth: Moisture laden clouds pushed upslope by winds condense to form a coastal rain."

Lead author Mate Adamkovics, a UC Berkeley research astronomer, noted that only areas near Xanadu exhibited morning drizzle, and not always in the same spot. Depending on conditions, the drizzle could hit the ground or turn into a ground mist. The drizzle or mist seems to dissipate after about 10:30 a.m. local time, which, because Titan takes 16 Earth days to rotate once, is about three Earth days after sunrise.

"Maybe only Xanadu has misty mornings," he said.

Adamkovics, de Pater and their colleagues in UC Berkeley's Center for Integrative Planetary Studies report their observation in the Oct. 11 issue of *Science Express*, an online version of the journal *Science*. They also will present their findings during a noon EDT press conference on Oct. 11 at the Division for Planetary Sciences meeting of the American Astronomical Society in Orlando, Fla.

Titan, larger than the planet Mercury, is the only moon in the solar system with a thick atmosphere, which is comprised mostly of nitrogen and resembles Earth's early atmosphere. Previous observations have shown that the entire moon is swathed in a hydrocarbon haze extending as high as 500 kilometers, becoming thinner with height. The south pole area exhibits more haze than elsewhere, with a hood of haze at an altitude between 30 and 50 kilometers.

Because of its extremely cold surface temperature - minus 183 degrees Celsius (-297 degrees Fahrenheit) - trace chemicals such as methane and ethane, which are explosive gases on Earth, exist as liquids or solids on Titan. Some level features on the surface near the poles are thought to be lakes of liquid hydrocarbon analogous to Earth's watery oceans, and presumably these lakes are filled by methane precipitation. Until now, however, no rain had been observed directly.

"Widespread and persistent drizzle may be the dominant mechanism for returning methane to the surface from the atmosphere and closing the methane cycle," analogous to Earth's water cycle, the authors wrote.

Actual clouds on Titan were first imaged in 2001 by de Pater's group and colleagues at Caltech using the Keck II telescope with adaptive optics and confirmed what had been inferred from spectra of Titan's atmosphere. These frozen methane clouds hovered at an elevation of about 30 kilometers around Titan's south pole.

Since then, isolated ethane clouds have been observed at the north pole by NASA's Cassini spacecraft, while both Cassini and Keck photographed methane clouds scattered at mid-southern latitudes. Also in 2005, the Huygens probe, build by the European Space Agency and released by Cassini, plummeted through Titan's atmosphere, collecting data on methane relative humidity. These data provided evidence for frozen methane clouds between 25 and 30 kilometers in elevation and liquid methane clouds - with possible drizzle - between 15 and 25 kilometers high. The extent of the clouds detected in the descent area was unclear, however, because "a single weather station like Huygens cannot characterize the meteorology on a planet-wide scale," said UC Berkeley research astronomer Michael H. Wong.

The new images show clearly a widespread cloud cover of frozen methane at a height of 25 to 35 kilometers - "a new type of cloud, a big global cloud of methane," Adamkovics said - that is consistent with Huygens' measurements, plus liquid methane clouds in the tropopause below 20 kilometers with rain at lower elevations.

Because earlier observers thought that the methane droplets in these clouds were too sparse to be seen, they referred to the frozen and liquid methane clouds as "sub-visible."

"The stratiform clouds we see are like cirrus clouds on Earth," Adamkovics said. "One difference is that the methane droplets are predicted to be at least millimeter-sized on Titan, as opposed to micron-sized in terrestrial clouds - a thousand times smaller. Since the clouds have about the same moisture content as Earth's clouds, this means the droplets on Titan are much more spread out and have a lower density in the atmosphere, which makes the clouds 'subvisible' and thus hard to detect."

If all the moisture were squeezed out of Titan's clouds, it would amount to about one and a half centimeters (six-tenths of an inch) of liquid methane spread around Titan's surface, Adamkovics said. This is about the same moisture content as some of Earth's clouds.

Since 1996, de Pater and colleagues have been using infrared detectors on the Keck telescopes to regularly monitor clouds and hazes on Titan. In past years, they have also used the VLT. The advantage of observing at infrared wavelengths is that Titan's haze is relatively transparent. At optical wavelengths, these haze layers form an impenetrable layer of photochemical smog.

By observing at different infrared wavelengths, scientists can probe different altitudes in Titan's atmosphere, depending on the strength of the methane absorption at that wavelength. Then, by using the methane absorption profile, they can pinpoint particular altitudes in Titan's atmosphere, allowing astronomers to see the surface and judge the altitude of methane clouds. Adamkovics first saw evidence of widespread, cirrus-like clouds and methane drizzle when analyzing Feb. 28, 2005, data from a new instrument on the European Southern Observatory's VLT - the Spectrograph for INtegral Field Observations in the Near Infrared (SINFONI).

Sharper images and spectra taken on April 17, 2006, by the OH-Suppressing Infra-Red Imaging Spectrograph (OSIRIS) on Keck II confirmed the clouds. Both instruments measure spectra of light at many points in an image rather than averaging across the entire image. By subtracting light reflected from the surface from the light reflected by the clouds, the researchers were able to obtain images of the clouds covering the entire moon.

"Once we saw this in both data sets, we altered our radiative transfer models for Titan and recognized that the only way to explain the data was if there was liquid or solid methane in the atmosphere," Adamkovics said. "This is a big step in helping us understand the extent to which solid clouds and liquids are spread throughout Titan's atmosphere."

UC Berkeley graduate student Conor Laver is the fourth author on the *Science Express* paper.

Source: University of California - Berkeley