Peeking behind the veil of Venus to study its weather

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The planet Venus is best known for the thick layers of clouds that veil its surface from view by telescopes on Earth. But the veil has holes, and a New Mexico State University scientist plans on using a solar telescope to peer through them to study the weather on Venus.

NASA's Pioneer Venus probe captured this image of Venus' perpetual cloud layer in 1979.

"Observations of Venus from a nighttime telescope at a single location are very difficult because Venus is so close to the Sun in the sky," said Dr. Nancy Chanover, a planetary scientist at NMSU in Las Cruces, NM. "You can observe it for about two hours at most." Then the Sun rises and blinds the telescope (or Venus sets, depending on the time of year).

"Alternatively you can find a telescope designed to be open when the Sun is above the horizon, and observe for several hours," Chanover continued. That's where the Dunn Solar Telescope at Sunspot, NM, comes into play. The Dunn is part of the National Science Foundation's National Solar

Observatory. While it has operated since 1969, it has rarely looked at the planets because it is smaller than most nighttime astronomy telescopes.

Since 2004, the Dunn has been equipped with high-order adaptive optics that iron out the wrinkles that Earth's atmosphere introduces into images of the Sun or any object in space. Effectively, the Dunn now sees seven times sharper than an equivalent, uncorrected telescope. That offers Chanover and Dr. Eliot Young, her colleague at Southwest Research Institute in Boulder, CO, the opportunity to observe Venus for several hours, from horizon to horizon and even after the sunrise. Their observations are scheduled during Feb. 10-15, 2006. Their work is funded by the National Science Foundation.

The veil of Venus is composed of thick clouds of sulfuric acid at altitudes from 48 to 70 km (30-43 miles) in a dense, unbreathable carbon dioxide and nitrogen atmosphere. The planet has virtually no water, thus inviting contrasts with Earth's weather and climate systems where water is all-important. But Venus's dingy yellow-white clouds block the view of its surface in visible light and even ultraviolet.

Infrared is a different matter, particularly around 2,300 nm, a wavelength about three times longer than the deepest red (about 770 nm) the human eye can see.

"This is a special wavelength where nightside clouds are relatively transparent and you see thermal radiation from the lower atmosphere peeking through the clouds," she explained. "It's significant in that you can compare what you see in the lower atmosphere with the ultraviolet views at the cloud tops and get a sense of how winds change with altitude."

The first measurements, by the four Pioneer Venus Probes as they plunged through the atmosphere in 1978, revealed winds that howl at up to 100 m/s (224 mph). This is called super-rotation because the winds are fast enough to circle the planet in five to seven days, 60 times faster than its 243-day rotational period. "Something unusual is going on here and it's poorly understood," she said.

Then scientists discovered in 1984 that near infrared light can escape from deep inside the atmosphere and even from the surface. In 1991 the Galileo spacecraft's infrared camera produced striking images of Venus' lower atmosphere as the craft flew by in 1990 on its way to Jupiter. A simultaneous ground-based campaign tracked cloud features for 5 to 17 hours and revealed complexities -- and uncertainties -- in the atmospheric circulation.

"With a time series of nightside images you will see cloud motions and you can take wind speed measurements at different latitudes and longitudes," Chanover explained.

"Nightside" is an important aspect of Chanover's observing plan because sunlight reflected from the dayside would overwhelm the view. The best observing is when Venus appears as a thin crescent and we see more of its nightside. It is also in the night sky the shortest period of time, thus making a daytime -- solar -- telescope attractive.

Chanover will observe at 2,295 nm wavelength using an infrared camera cooled with liquid nitrogen. The camera was developed for infrared polarimetry to explore the relatively unknown infrared region of the Sun's spectrum. A new narrowband filter has been added to concentrate on the 2,295 nm light emitted deep in Venus' atmosphere. Clouds higher in the atmosphere absorb this band, so Chanover and Young can track the silhouettes.

Chanover also has observed Venus with ground-based telescopes, including the 3.5-meter telescope at the Apache Point Observatory next to Sunspot, on three previous occasions. This round with the Dunn is part of a larger campaign involving several telescopes including Apache Point. But she hopes the Dunn's adaptive optics will provide sharper images over a longer time interval each day than other telescopes have achieved.

"With the combination of adaptive optics and longer temporal baselines, we're hoping to increase the number of features we can track and the number of latitude points where we can measure wind speeds," she said.

"I want to emphasize that the importance of the Dunn observations is the combination of high spatial resolution and the extended temporal coverage of the cloud motions," Chanover said. "Observing during the daytime with a solar telescope enables us to track features for two, four, even six hours at a time, whereas most other nighttime facilities are limited to one or two hours. We'll really need the Dunn's adaptive optics to maintain good seeing on Venus throughout the morning as the surface of the Earth starts to heat up."

If the Dunn and its adaptive optics work as planned, Chanover expects that it will add a new tool to those now used by planetary astronomers. Chanover's technique will also complement detailed measurements by Europe's Venus Express orbiter, which arrives in April.