

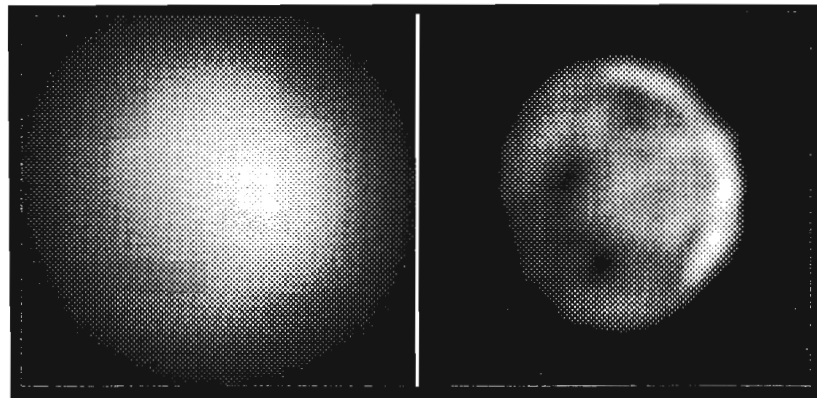
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## **FORECASTING DUST STORMS ON MARS: SPECKLE IMAGING HELPS SCIENTISTS SEE STORMS WHICH MAY THREATEN FUTURE MISSIONS**

A relatively new astronomical observing technique known as speckle imaging may help scientists gain a better understanding of the massive dust storms which periodically envelop the planet Mars. Information about the storms is crucial for planning manned space missions to the red planet -- and could also provide insight into terrestrial concerns about global climate change.

Scientists from the Georgia Tech Research Institute (GTRI) and California Institute of Technology's Jet Propulsion Laboratory (JPL) hope to produce a long-term record of Martian weather using the technique. The information would help answer questions about the frequency



*Most of the year, it is difficult to see details on Mars through ground-based telescopes (l). Speckle reconstruction reveals enough detail to distinguish major features (r) and large storms.*

of the storms -- and perhaps even allow scientists to predict when they will occur.

Georgia Tech scientists have already demonstrated that speckle imaging can provide pictures with enough detail to detect the storms.

The observing project relies on a series of high-speed "snapshots" taken through a telescope with a special charge-coupled device (CCD) camera and data recorder designed and built at Georgia Tech. Sophisticated computer algorithms analyze the snapshots to reconstruct an image of Mars, giving

scientists a way to overcome the blurring caused by the Earth's atmosphere, explained Dr. James Beletic, a Georgia Tech research scientist.

The apparent size of Mars as seen from Earth changes dramatically as the distance between the planets changes over a 780-day cycle. Because of atmospheric blurring, conventional ground-based telescopes can clearly see Mars for only about 10 percent of that time.

"We have demonstrated that we can monitor Mars for

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large dust storms on a routine basis," said Beletic. "The images should be better than anything you can get of Mars on a regular basis from conventional telescopes."

Preliminary images produced by the system offer enough quality to distinguish the large dust storms which are of the most concern to space scientists, said Dr. Richard Zurek, a JPL scientist. The technique may also show regional storms, the next smallest category, though it will not be able to detect the local storms from which the larger disturbances develop.

During most of the year, conventional telescopes have difficulty seeing Mars because turbulence in the Earth's atmosphere shifts the incoming light waves out of phase, jumbling the image details.

But by using extremely short exposure times -- on the order of 20 milliseconds -- Beletic's camera system can "freeze" the blurring and then reconstruct the details.

"The image we get through a blurry atmosphere is a combination of whatever object we are looking at and the blurring of the atmosphere," he explained. "If you take a picture fast enough to freeze the blurring of the atmosphere, you have a distinct image. Then if you take another picture of the same object, the blurring will be different. You can then use computer algorithms to sort out what stayed the same in all of the images."

Taking high-speed pictures of relatively faint objects such as distant planets requires an extremely sensitive camera able to record images with little "noise." To obtain the necessary performance, the researchers received help -- and a special CCD chip -- from Lincoln Laboratories at the Massachusetts Institute of Technology.

The equipment records approximately four megabytes of data each second, but because of the short exposure times, only a few minutes are required to obtain the thousands of images necessary to do the analysis. After processing, said Beletic, effectively only about one in every 10,000 photons recorded by the equipment actually contributes information to the final image.

Except when the planet is very near the Earth, conventional telescopes produce Mars images with resolution little better than one arc-second -- not enough to see much detail. The first speckle images, taken in the spring of 1991 at the University of Hawaii's 88-inch telescope, provided a resolution of 0.3 arc-second. Beletic and his colleagues have shown that 0.1 or 0.15 arc-second

resolution images can be regularly obtained when a high-speed recorder is correctly interfaced to the camera system.

Mars dust storms could affect future space missions in a number of ways, Zurek noted. By altering the density of the thin Martian atmosphere, the dust could affect the aerobraking and aerocapture procedures spacecraft would use to initiate orbits around the planet. Suspended grit could also damage spacecraft shields.

Near the surface, the same grit could clog delicate working parts, while the reduced amount of sunlight would cut power generated by solar cells. The storms would also limit visibility on the surface, while electrostatic energy generated by the dust in the dry atmosphere could jolt delicate electronic devices, Zurek added.

"In terms of the comfort and ease of operations on the surface of Mars, there are a lot of things that may need to be taken into account," he explained. "There are ways to design around it, but it would be helpful to know how often dust would be raised into the atmosphere."

By blocking sunlight, Martian dust storms cause immediate climate changes comparable to what some scientists fear could happen on Earth through volcanic eruptions or the impact of small asteroids. By trapping infrared radiation, suspended dust can also produce a Greenhouse Effect. Though the changes on Mars are exaggerated by the planet's unique climate, more knowledge of their workings could help scientists understand our own planet's complex atmosphere.

"Mars has shown us that raising dust into the atmosphere can significantly alter the thermal structure and circulation of the atmosphere," he explained. "Mars carries out this experiment for us on a fairly short time scale."

Information on this work was presented to the High Resolution Imaging by Interferometry Conference held in Garching, Germany October 14-18. A paper describing it has been submitted to [Applied Optics](#).

The research has been sponsored by internal GTRI funds, but a proposal has been made to NASA for a three-year research effort.

**EDITOR'S NOTE:** Copies of the comparison images shown on the previous page, as well as color slides and black & white prints of Dr. Beletic with the speckle imaging equipment, are available.