Cloud-chamber experiments show that clouds on Mars form in much more humid conditions than clouds on Earth

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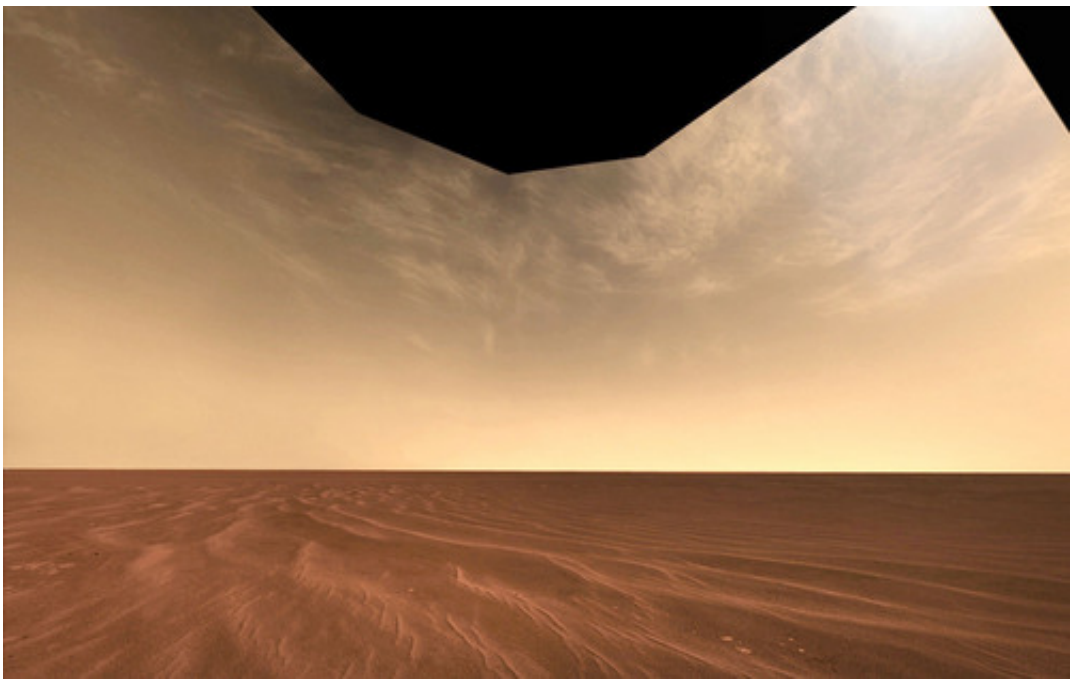

Clouds captured above a vast plain of sand by the Opportunity rover near Victoria Crater on Mars on October 2006. Credit: NASA

At first glance, Mars' clouds might easily be mistaken for those on Earth: Images of the Martian sky, taken by NASA's Opportunity rover, depict gauzy, high-altitude wisps, similar to our cirrus clouds. Given what scientists know about the Red Planet's atmosphere, these clouds likely consist of either carbon dioxide or water-based ice crystals. But it's

difficult to know the precise conditions that give rise to such clouds without sampling directly from a Martian cloud.

Researchers at MIT have now done the next-best thing: They've recreated Mars-like conditions within a three-story-tall cloud chamber in Germany, adjusting the chamber's temperature and relative humidity to match conditions on Mars—essentially forming Martian clouds on Earth.

While the researchers were able to create clouds at the frigid temperatures typically found on Mars, they discovered that cloud formation in such conditions required adjusting the chamber's relative humidity to 190 percent—far greater than cloud formation requires on Earth. The finding should help improve conventional models of the Martian atmosphere, many of which assume that Martian clouds require humidity levels similar to those found on Earth.

"A lot of atmospheric models for Mars are very simple," says Dan Cziczo, the Victor P. Starr Associate Professor of Atmospheric Chemistry at MIT. "They have to make gross assumptions about how clouds form: As soon as it hits 100 percent humidity, boom, you get a cloud to form. But we found you need more to kick-start the process."

Cziczo says the group's experimental results will help to improve Martian climate models, as well as scientists' understanding of how the planet transports water through the atmosphere. He and his colleagues have reported their findings in *Journal of Geophysical Research: Planets*.

Seeding Martian clouds

The team conducted most of the study's experiments during the summer of 2012 in Karlsruhe, Germany, at the Aerosol Interaction and Dynamics in the Atmosphere (AIDA) facility—a former nuclear reactor that has since been converted into the world's largest cloud chamber.

The facility was originally designed to study atmospheric conditions on Earth. But Cziczo realized that with a little fine-tuning, the chamber could be adapted to simulate conditions on Mars. To do this, the team first pumped all the oxygen out of the chamber, and instead filled it with inert nitrogen or carbon dioxide—the most common components of the Martian atmosphere. They then created a dust storm, pumping in fine particles similar in size and composition to the mineral dust found on Mars. Much like on Earth, these particles act as cloud seeds around which water vapor can adhere to form cloud particles.

After "seeding" the chamber, the researchers adjusted the temperature, first setting it to the coldest temperatures at which clouds form on Earth (around minus 81 degrees Fahrenheit). Throughout the experiment, they cranked the temperature progressively lower, eventually stopping at the chamber's lowest setting, around minus 120 Fahrenheit—"a warm summer's day on Mars," Cziczo says.

By adjusting the chamber's relative humidity under each temperature condition, the researchers were able to create clouds under warmer, Earth-like temperatures, at expected relative humidities. These observations gave the researchers confidence in their experimental setup as they attempted to grow clouds at temperatures that approached Mars-like conditions.

Dialing the temperature down

Over a week, the group created 10 clouds, with each cloud taking about 15 minutes to form. The chamber is completed insulated, so the researchers used a system of lasers, which beam across the chamber, to detect cloud formation. Any clouds that form scatter laser light; this scattering is then detected and recorded by computers, which display the results—the size, number, and composition of cloud particles—for scientists outside the chamber.

By analyzing this data over the following six months, the researchers found that clouds that grew at the lowest temperatures required extremely high relative humidity in order for water vapor to form an ice crystal around a dust particle. Cziczo says it's unclear why Martian clouds need such humid conditions to take shape, but hopes to investigate the question further.

Toward that end, the group plans to return to Germany next fall, when the chamber will have undergone renovations, enabling it to perform cloud experiments at even lower temperatures—conditions that may more closely mimic the icy atmosphere on Mars.

"If we want to understand where water goes and how it's transported through the atmosphere on Mars, we have to understand cloud formation for that planet," Cziczo says. "Hopefully this will move us toward the right direction."

More information: onlinelibrary.wiley.com/doi/10 … /jgre.20155/abstract

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