# Study quantifies global impact of electricity in dust storms on Mars

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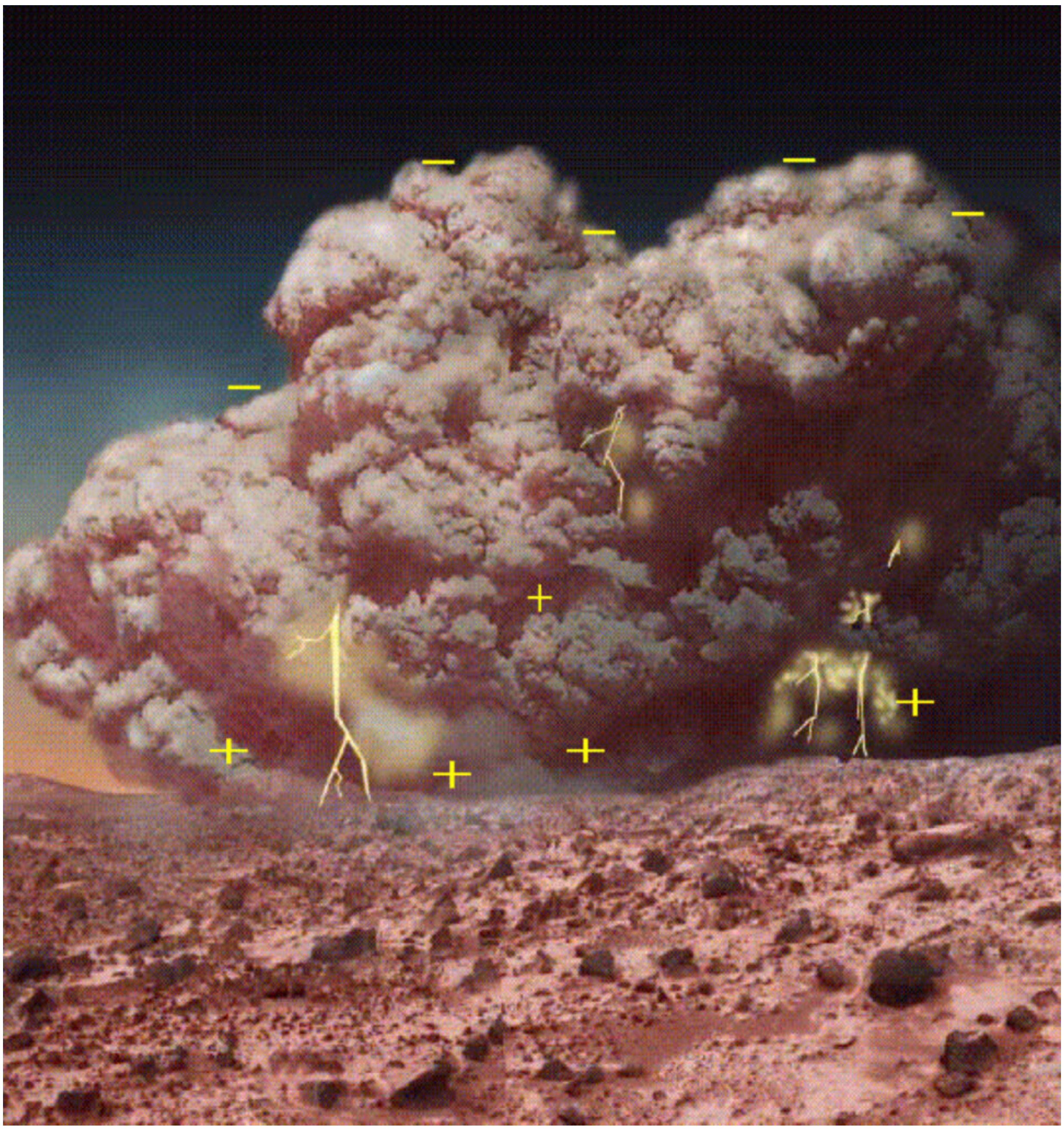


An artist’s impression of electricity in a Martian dust storm. Credit: NASA

Mars is infamous for its intense dust storms, some of which kick up enough dust to be seen by telescopes on Earth.

When dust particles rub against each other, as they do in Martian dust storms, they can become electrified, transferring positive and negative electric charge in the same way as you build up static electricity if you shuffle across a carpet.

Strong electric fields build up in dust storms on Earth, so it is perhaps unsurprising that this also happens on Mars. But what happens next? Probably not a sudden flash of lightning, as we might expect on Earth.

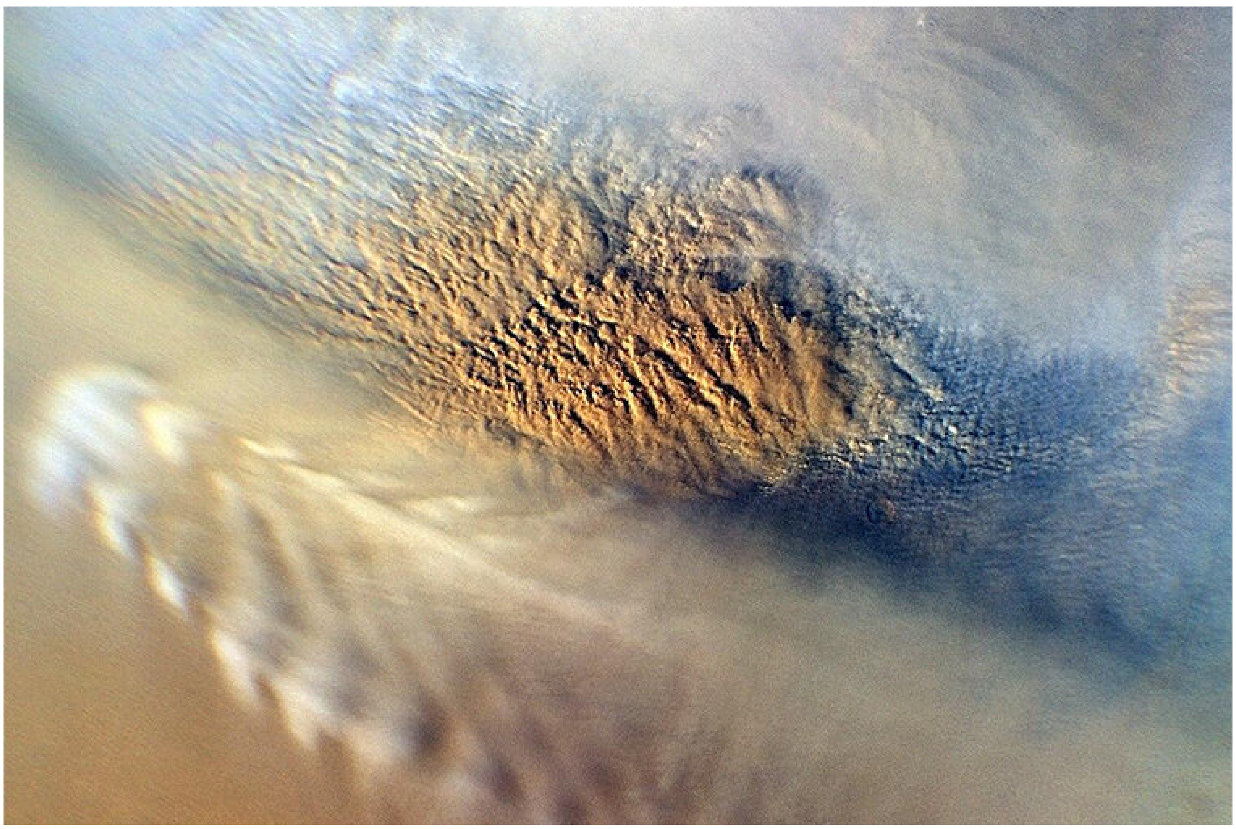
Instead, planetary scientist Alian Wang at Washington University in St. Louis thinks electrical discharge on Mars probably looks more like a faint glow. (None of the Mars landers, rovers or other missions have captured a real picture of it.)

"It could be somewhat like the aurora in polar regions on Earth, where energetic electrons collide with dilute atmospheric species," said Wang, a research professor of earth and planetary sciences in Arts & Sciences.

Flashy or not, this Martian "faux-rora" still packs a hefty punch.

Wang's new study in the journal *Geophysical Research Letters* shows that electricity in dust storms could be the major driving force of the Martian chlorine cycle.

As background, scientists consider chlorine one of five elements that are "mobile" on Mars (the others are hydrogen, oxygen, carbon and sulfur). This means chlorine, in different forms, moves back and forth between the surface and the atmosphere on Mars. On the ground, chloride deposits—which are similar to saline playas or shallow salt flats on Earth—are widespread. These chloride deposits likely formed in the early history of Mars as precipitated chloride salts from brine.



NASA's Mars Reconnaissance Orbiter captured this close-up image of a dust storm in November 2007. Credit: NASA

In the new study, Wang shows that one particularly efficient way to move chlorine from the ground to the air on Mars is by way of reactions set off by electrical discharge generated in Martian dust activities.

Wang and her collaborators conducted a series of experiments that obtained high yields of chlorine gases from common chlorides—all by zapping the solid salts with electrical discharge under Mars-like conditions. They conducted these experiments using a planetary simulation chamber at Washington University (called the Planetary Environment and Analysis Chamber, or PEACh).

"The high-releasing rate of chlorine from common chlorides revealed by this study indicates a promising pathway to convert surface chlorides to the gas phases that we now see in the atmosphere," said Kevin Olsen, a research fellow at The Open University, in the United Kingdom, and a co-author of the new study.

"These findings offer support that Martian dust activities can drive a global chlorine cycle. With the ExoMars Trace Gas Orbiter, we see repeated seasonal activity that coincides with global and regional dust storms," he said.

## Easier on Mars than on Earth

"Frictional electrification is a common process in our solar system, with Martian dust activities known to be a powerful source of electrical charge buildup," said Wang, who is a faculty fellow of the university's McDonnell Center for the Space Sciences. "The thin atmosphere on Mars makes it much easier for accumulated electrical fields to break down in the form of electrostatic discharge. In fact, it's a hundred times easier on Mars than on Earth."

Scientists involved in the Viking missions that landed on Mars in the 1970s first proposed that dust storms might be a source of the new reactive chemistry on the red planet.

However, the chemical effects of dust activities were difficult to study. Certain mission opportunities, like the ExoMars Schiaparelli EDM launched in 2016, ended in failure. Scientists turned to models and experimental studies.

NASA's Mars Reconnaissance Orbiter captured this image of a dust devil winding its way along the Amazonis Planitia region in March 2012. Credit: NASA

In recent years, Wang and other scientists have published research that shows that when electrostatic discharge interacts with chlorine salts in a Mars-like carbon dioxide-rich environment, it can generate perchlorates and carbonates, and also release chlorine as a gas.

But this new study is the first to try to quantify just how much of these chemical products are actually produced during dust storm events.

"The reaction rates are huge," Wang said. "Importantly, the released chlorine in a short-time mid-strength electrostatic discharge process is at a percent level." This means that during a seven-hour simulated electrostatic discharge experiment, at least one out of every 100 chloride molecules is decomposed and then releases its chlorine atom into the atmosphere.

Similar but slightly lower, the formation rates of carbonates and perchlorates are at sub-percent and per-thousand levels, Wang said.

These high yields lead Wang and her team to believe that Martian dust activities can be linked to three global phenomena recently revealed by Mars missions.

Electrical discharge can be tied to the extremely high concentrations of perchlorate and carbonate globally in Martian topsoil, she said. Quantitatively, the high end of the observed concentration ranges can be accumulated by dust storm-induced electrical discharge within less than half of the Amazonian period, the most recent period of Mars's history, which is thought to have begun about 3 billion years ago. Also, the high yield of released chlorine atoms from chlorides can account for the high concentrations of hydrogen chloride observed in the Martian atmosphere during the 2018 and 2019 dust seasons, when assuming 1 to 10 cm thickness of Martian surface dust would be kicked up by a global dust storm.

"No other process that we know of can do this," Wang said, "especially with such quantitatively high yield of chlorine release."

**More information:** Alian Wang et al, Quantification of Carbonates,

Oxychlorines, and Chlorine Generated by Heterogeneous Electrochemistry Induced by Martian Dust Activity, *Geophysical Research Letters* (2023). DOI: 10.1029/2022GL102127

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